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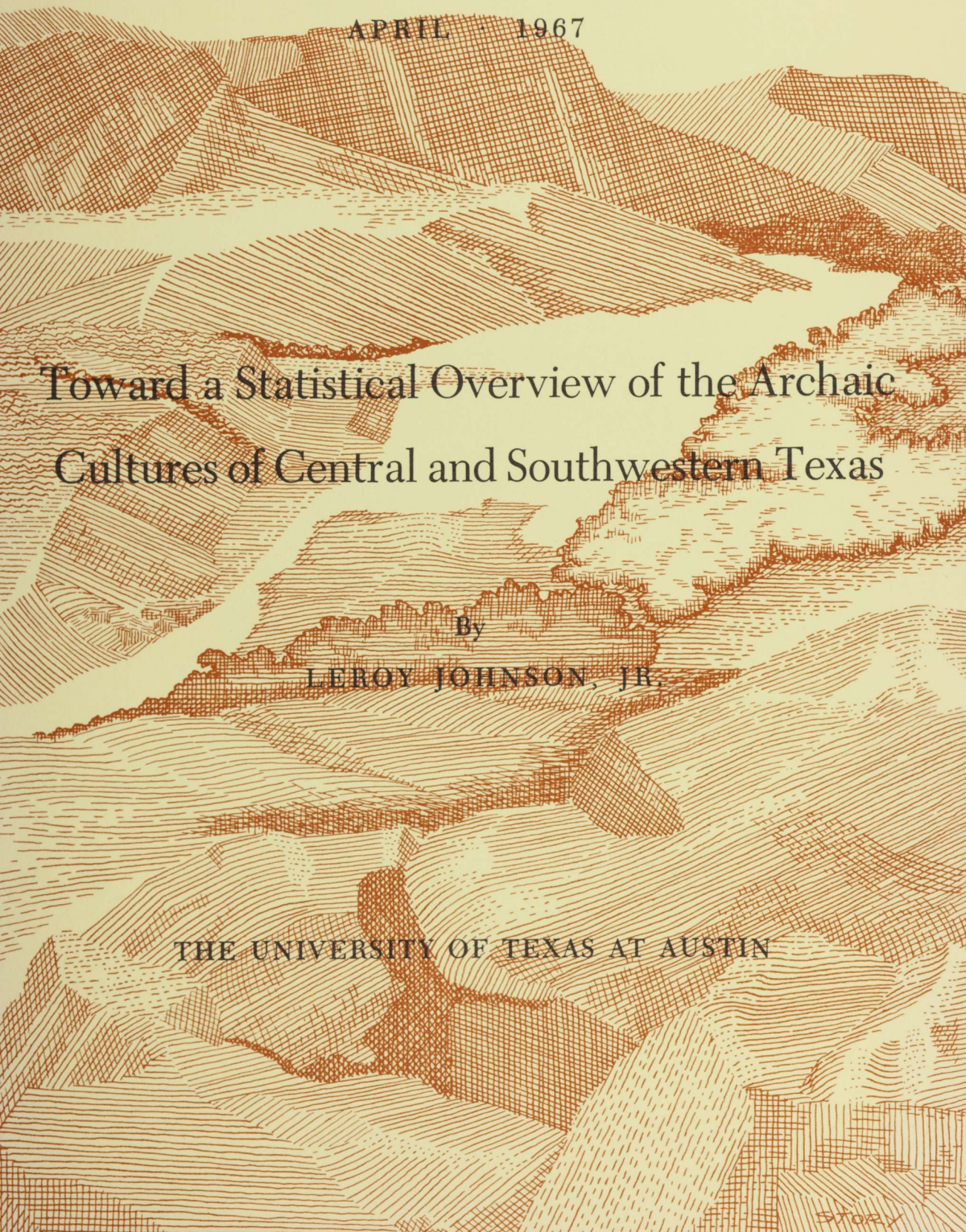

Toward a Statistical Overview of the Archaic Cultures of Central and Southwestern Texas

By

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THE UNIVERSITY OF TEXAS AT AUSTIN

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Abstract

Total lithic artifact collections from nine Texas sites are compared here by a simple form of cluster analysis with ordered matrix. Roark Cave, Coontail Spin Rockshelter, Centipede Cave, and the Devil's Mouth Site occur in the desertland of southwestern Texas, while the Wunderlich Site and the Levi, Oblate, Smith, and Kyle rockshelters are located in the semi-wooded hills of central Texas. All are simple middens without discrete occupational components. Since component recognition is necessary for archeological unit definition, a culture-historical integration of the archeological data from these sites must be achieved by some other means. This paper develops a comparative method suitable for this task.

Lithic artifacts from site columns are isolated into collections representing given intervals of time, described typologically, and compared quantitatively to produce Robinson (1951) indexes of agreement. These indexes are grouped into clusters by matrix analysis, to reveal spatial-temporal patterns of uniformity amenable to cultural and ecological interpretations.

Index clusters are plotted in time and space. This plotting shows (1) that the desert area of southwestern Texas is more stable, archeologically, from one period to another than the semi-wooded area of central Texas, and (2) that the two areas stand apart as separate archeological provinces throughout much of their histories.

Acknowledgments

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Introduction

The corpus of archeological information which has been amassed in Texas since the commencement of post-war salvage excavations is impressive. And it is constantly being added to by the field activities of university students, by amateur excavations of an increasingly more sophisticated sort, and by more and more federally sponsored salvage. The point has clearly been reached where the archeologist needs to disengage himself, for a while at least, from the frenzy of field and laboratory activity, from the many collections of artifactual data, and from the omnipresent task of preparing site reports, in order to take an objective look at what has been accomplished to date. It is time, in other words, to take stock, to ask specific questions of our archeological data and to judge the success of our field and laboratory studies in providing acceptable answers to these questions.

Let us take up one of the weightiest of the questions which can be formulated. Are there patterns of general uniformity (specifically, in lithic toolkits) in the Archaic cultures of central and southwestern Texas? If so, how may they be recognized and given formal expression? Most archeologists would agree that one of the foremost objectives of prehistoric archeology is to carry out comparisons which show both similarities and dissimilarities important to culture-historical and sociocultural interpretations. The pursuance of this goal of pattern recognition takes many paths, including artifact attribute analysis, trait distribution studies, artifact typology, the creation of subsistence and settlement pattern taxonomies, and the definition of archeological culture units. The list could be expanded considerably.

The patterns of general uniformity which will be sought after here are the holistic patterns in archeological data of the type normally conceptualized as *units* (phases, foci, aspects, etc.). Attempts to define archeological units in the semi-wooded hills of central Texas and the desert of southwestern Texas have fallen far short of the mark, and, further, recent field work has done virtually nothing to better the situation. Whether this is the fault of excavation procedures, or a reflection of the homogeneous nature of the habitation sites, is a problem that needs to be carefully considered. Whatever the reason, separate occupational components have not been recognized in the excavated sites of central and southwestern Texas. Since the lack of such components automatically precludes the definition of common types of archeological units such as phases, and since unit definition is the usual way of recognizing and formalizing patterns of uniformity, then some alternative method has to be introduced. The problem faced here is not unique to Texas. It is one to be met in many regions throughout the world such as the Great

Basin, northern Mexico, the Argentine, etc., where midden sites often lack recognizable components.

In lieu of unit (phase) definition, it is proposed (1) that artifacts from site profiles be isolated into groups representing comparted intervals of time and (2) that these groups of artifacts be compared by descriptive statistics to produce numerical indexes of their similarity. Once calculated, these indexes can be used to reveal temporal and spatial patterns of uniformity.

What is envisioned, then, is a statistical overview of the Archaic sites of central and southwestern Texas. If components could be recognized in the sites, descriptive statistics of several kinds could be used to group them into culture units; but this cannot be done. Patterns of another sort can be defined, however—patterns which do not necessarily represent a particular social group as do those based on the recognition of discrete site components. This paper is directed toward developing a technique for determining such patterns.

To be more specific as to technique, the grouping and determination of relative temporal equivalence of artifact collections is done, in approximate form, by means of a series of specific lithic artifact forms called period markers. The comparison of artifact collections from "periodized" strata is accomplished by computing indexes of similarity after the fashion of Robinson (1951) and Brainerd (1951); the indexes are then analyzed graphically according to the matrix method first used in archeology by Kroeber (1940). This is a simple kind of cluster analysis whose use in anthropology goes back at least to the turn of the century. A new computer program now makes it possible to refine matrix ordering in such a way that cluster definition within the matrix can be done more objectively, more accurately, and more rapidly, than heretofore.

Clusters thus defined are patterns of uniformity which can partially substitute for archeological phases or other units, since they can serve for cultural studies of broad scope such as the determination of geographical boundaries of archeological provinces, the calculation of the rate of change in total artifact collections, and the study of the relationship between natural environment and the temporal stability of artifact inventories. Heretofore, quantitative comparisons of this type in archeology have been used almost exclusively for temporal seriation, although they are certainly not limited to that kind of problem.

The matrix form of cluster analysis is only one of many techniques, both graphical and numerical, which can be employed to generate statistical overviews of large amounts of information. Factor analysis, numerical cluster analysis, cumulative frequency graphing, and other techniques are available and will be mentioned in the text. Matrix clustering with Robinson indexes of agreement, however, is deemed the simplest and most appropriate technique for the data which are available at the present.

There is a point which must be emphasized at the outset. And this is that

the study, as its title indicates, is a preliminary attempt at synthesis, one which, by necessity, must partially fail to accomplish its major aim. The sample of sites for some areas and periods is too limited for an ideal comparison; the published descriptive data too inconsistent and too fragmentary to warrant optimal inter-site comparison; and the artifact samples which have to be used are too small to allow for statistical comparison *sensu stricto,* according to the laws of probability which govern sample differences.

In spite of this impressive list of limitations, two things are accomplished. Perhaps the most important of them is that gaps and inconsistencies in excavation technique, artifact typologies, and site reporting emerge which might not otherwise be seen if a statistical comparison of numerous sites were not undertaken. With the usual "essay" definition of units, inconsistencies do not emerge so clearly.

There is hopefully a second accomplishment. Although the sample size, both in terms of the number of periodized artifact collections and the number of artifacts per collection, is small (and therefore differences between them would often have to be ascribed to the vagaries of sampling if probability statistics were brought in), patterns do emerge and suggest several important differences between the Archaic cultures of the humid, semi-wooded hills of central Texas and the desertland of the southwestern part of the state. These patterns are *not* of the random sort one would expect if inter-site and areal differences were due only to sampling error. Whether the findings of the study are disavowed by future work or not (and such is easily possible), there is an heuristic value in attempting a statistical overview at this stage of our knowledge of Texas archeology, so that past work can be evaluated and future strategy formulated more clearly.

The Problem of Component Recognition as it Relates to Archeological Unit Definition in Texas

Before progressing to the statistical study, it is necessary to illustrate the conditions under which unit identification is precluded, drawing on data from central and southwestern Texas. The discussion will include a review of the unit concept itself, to determine the appropriateness and limitations of its application to archeological data.

The Methodology of Unit Definition

The term *unit* is normally used by North American archeologists in the sense that it is a terminological recognition of relatively uniform archeological trait assemblages called, variously, phases, cultures, foci, aspects, etc., depending on their magnitude and the system of nomenclature being used. A unit so conceived must possess a unique combination of traits which are the concrete reflection of an individual community, or very similar group of communities.* This is the *basic archeological unit* of Willey and Phillips (1958: 21–24) recognized by virtue of its formal content. The all-important element of content is only one of a unit's dimensions; two others are its spatial extent and temporal limits.

In their review of American archeology and its methodology, Willey and Phillips (1958) affirm that there is, happily, at least one point of agreement among contemporary American archeologists: namely, that "culture-historical integration"† should treat both the spatial-temporal dimensions and the formal content and relationships of data. Any of the taxonomic systems which deal with archeological units should concern themselves with all of these factors, although individual units within a system may emphasize one factor or dimension to the near exclusion of others.

The determination of the formal content of units is the first step in their definition. To assign a collection of artifacts to an archeological unit, it is necessary to show that they actually represent the remains of a discrete community, or interrelated series of communities, which can be isolated in space and time. A close contextual relationship among archeological ma-

* The term *community* is used here in the sociological sense, instead of a less definite term such as "local group." According to Murdock (1949: 79), it is the maximal group of persons who normally reside together in face-to-face association.

† In a strict sense, culture-historical integration is the process of defining culture forms (or patterns), plotting these forms in space and time, and determining their relationships.

terials is demanded for this kind of assignment. This shall be called a *cultural association.*

Many cases of cultural association come readily to mind. In all of them, the context of the association is such that we can be relatively sure the artifacts were used by the same social group. Artifacts found together as part of a single lot of burial furniture are one good example. If the artifacts were included with the corpse at time of interment, we know that they all characterize a single community. Since, however, burial fill may contain artifacts of other periods and people, the archeologist is obliged to study the context of the burial. A group of projectile points lying near the corpse and all oriented in the same direction indicate the deliberate inclusion of a bundle of arrows, whereas single projectile points may represent accidental inclusions. The same can be said about individual potsherds as opposed to batches of sherds from vessels obviously placed in a burial. Artifacts found in storage pits can also be considered culturally associated if, from their arrangement, it appears that they were deliberately placed in the pits and were not included with fill in later years.

Artifacts in direct association with recognizable house floors or fire hearths may also be culturally associated, although there are pitfalls to their correct interpretation. If it is clear that they were used in conjunction with the house or hearth, then they can be considered correctly associated. Artifacts trodden into a house floor were obviously used by the inhabitants, as were entire broken pots which might occur on the floor. However, if an abandoned house were gradually covered, or filled in, by later debris produced by other peoples, many items might occur in accidental association with the floor. It is up to the archeologist to play the role of sleuth and reconstruct the context of the association in order to recognize and eliminate accidental associations whenever possible.

The same thing applies to fire hearths. In simple camp sites hearths are one of the few features the archeologist is apt to find. Artifacts (of stone, bone, pottery, etc.) are often found about the rim of the hearth or even with its ashes. Here it is more difficult to distinguish between tools left at the hearth site while it was being used, and later artifacts from overlying soil zones which have accidentally come in contact with the hearth. However, cultural association can be demonstrated in cases where artifacts were burned or thrown into the hearth, or where they were covered by charcoal and ash emptied from it.

As any site is excavated, numerous cultural associations should be defined —in burials, house floors, etc. When this is done, a comparison should be made of association lots to try to determine which artifact forms or types, and which features, are the remains of discrete communities, *i.e.*, individual site components. For instance, if the formal composition of artifact lots from

"House 1," "Burial 2," and "Hearth 1" is similar, the archeologist may wish to assign them to the same component. Physical evidence such as the association of the features with a living surface, their similar depth below the surface, etc., can be used to check this kind of component recognition. The job is far from easy, but any definition of archeological units should adhere to this approach. W. W. Taylor, in *A Study of Archeology* (1948), shows an awareness of the necessity for recognizing cultural associations, and his statement is to the point. He rightly maintains that culture units should represent given groups of people.

> Cultural materials . . . represent the local group that made, used, or possessed them in the past. Since the local human groups represented by these localized finds are the only empirical ones with which the archaeologist of non-literate and undocumented cultures deals, they are basic and constitute the starting point of all archaeological taxonomy (pp. 146, 147).

V. Gordon Childe, in his *Prehistoric Migrations in Europe* (1950), demonstrates a complete awareness of the problem. To define "cultures" (his archeological units) an archeologist must be able to demonstrate conclusively that traits, artifacts, etc., relate contextually to one another in such a way that we know them to be the concrete expressions of the common social traditions of a single people. Although Childe places most of his emphasis on "social tradition," it is clear that he realizes fully the need for observing cultural associations, as shown by his demand for the recognition of clear contextual relationships.

Archeologists who have habitually worked in regions and with archeological materials where good contextual relationships are available have seldom deemed it necessary to verbalize the matter of determining cultural associations. This is so, principally, because it has been comparatively easy in such areas to classify materials into units which stand for the material remains of individual communities of people. A review of the most widely accepted classificatory systems used in North America today shows that the recognition of cultural associations is a vital part of the operational procedure which underlies unit definition. Unfortunately, this has not always been spelled out clearly.

W. C. McKern (1939: 308) has stated, in discussing the procedure to be followed in defining foci, that:

> Starting at the site, as any investigator must, materials and associated data are collected which have cultural significance. Expressed in terms of culture traits, these data provide a trait complex for the site. If the complex of trait units so determined, or any important complex of trait units included therein, is found to recur in characteristic purity and practical completeness, this recurring complex establishes the first of our class type, the *focus*. A focus may be briefly defined as that class of

culture exhibiting characteristic peculiarities in the finest analysis of cultural detail, and may in instances correspond closely to the local tribe in ethnology.

This quotation illustrates that McKern intended his focus to stand for the remains of definite groups of people, recognizable at one or more archeological sites as individual components. Yet he is not explicit in stating exactly how components should be discovered although the mention of "characteristic purity and practical completeness" leads me to think that he had in mind artifacts found in tight cultural association with one another. Whether McKern realized it or not, the use of cultural associations has to be the basis for correct component, and hence focus, recognition. In spite of McKern's failure to be sufficiently explicit about the need for determining cultural associations, this procedure *must* be followed if the Midwestern Taxonomic System is to be used effectively.

There have been numerous inaccurate applications of the Midwestern system, although many of the foci which have been established in the Midwest, the Eastern U. S., and the Great Plains (areas where the Midwestern Taxonomic System has been used extensively) have been defined by recognizing cultural associations in sites, and the evidence has usually been adequate to justify the conclusion that given artifacts were, in fact, actually manufactured by recognizable communities of people. Grave lots have been segregated from each other for comparative study, and artifacts associated with architectural and burial structures have also been isolated.

In discussing their idea of *phase*, Willey and Phillips (1958: 22) indicate (1) that it is an archeological unit having characteristic traits which set it apart from all other such units, (2) that it occurs within a locality or region, and (3) that it is limited in time to a relatively brief interval. And in treating the problem of recognizing components of phases, they say that (p. 49):

> The social equivalent of the component is the "community," as defined by Murdock and others. . . . The equivalent of phase, then, ought to be "society," and in a good many cases it probably is.

From this statement it is obvious that phase components can only be defined by isolating archeological materials into associational units. It is difficult to understand why the methodology of component recognition is not given more attention by Willey and Phillips. However, the implications of their discussion in this direction are perfectly clear. In another source (Willey and others 1956: 5) Willey says that:

> The importance of associations [of material objects] in archaeological research cannot be overestimated because they reflect human behavior outside of the limits of what ethnologists call "material culture." . . .

Although Willey's reference above is to the study of non-material aspects of

culture, which are irrelevant here, his mention of "associations" demonstrates his awareness of the problems presented in this chapter.

The attention which Willey and Phillips have given to their use of terms such as *component* and *phase* makes it easy to see not only the utility of perceiving cultural associations in sites, but the necessity for this operation if culture units are to be defined. Other writers have not made this patent in their discussions of archeological units.

It is difficult to judge just how cognizant current prehistoric archeologists are of the present problem—the physical recognition of individual components by means of cultural associations. My impression is that awareness is growing but is far from universal. Two recent papers on archeological theory and methodology by Binford (1964) and Tugby (1965) show opposing views on the subject.

Lewis R. Binford, in "A Consideration of Archeological Research Design" (1964), discusses the broad problem of areal research. Among other considerations, Binford points out the necessity of determining the depositional conditions of individual sites so that "activity loci" of single components may be discerned. His interest lies with analyzing the activity loci (areas of task performance) for a reconstruction of behavior in single cultures [societies]. The emphasis is on the analysis of cultural process of a type which cannot be done with the available data from the Texas sites studied here. However, Binford shows an awareness of the problem of component recognition, although he does not discuss cultural associations as a method for component definition in the same way done here. The label is different, but his "activity loci" are very close in their physical content to "cultural associations." Burials, house floors, fire hearths, etc., can be viewed as loci for different kinds of social activities.

Donald J. Tugby, of the University of Queensland, Australia, has just published a much needed paper on archeological statistics and their application. In his "Archaeological Objectives and Statistical Methods: A Frontier in Archaeology" (1965), Tugby classifies archeological goals and discusses available statistical techniques which can aid in their study. Unfortunately, the paper is weak in its treatment of artifact collections. The basic idea presented by Tugby is that artifact types which are consistently found together constitute a characteristic assemblage (p. 4). Furthermore, he maintains that assemblages that are sufficiently like one another can be regarded as representatives of a single component, and such assemblages can be discovered by statistical techniques. Thus the statement is made that one of the objectives of the process of analysis is ". . . the identification of assemblages by association of morphological types. The appropriate archeological unit is the component, an assemblage confined to one site and forming a part of a more wide-

spread phase" (p. 8). Q-type factor analysis is recommended for this kind of assemblage recognition.

The error here is that "association" is conceived only in a statistical, as opposed to a physical, sense. Similar artifact assemblages can be found at different sites which nevertheless represent mixed components. No statistical technique is able to recognize this mixture. Only a detailed study of cultural associations can demonstrate which artifacts are "associated" in a cultural sense. Tugby's Q-type factor analysis could easily lump together materials found in one stratigraphic context which nevertheless are from separate occupations.

Hindrances to Unit Definition in Texas Middens

The somewhat special characteristics of central and southwestern Texas habitation sites may explain their lack of cultural associations. (This is not to say, however, that cultural associations cannot be found if improved excavation techniques are adopted.) They are (1) exposed areas of midden soil found along small streams and near springs, (2) buried lenses of midden soil in alluvial terraces along large rivers, and (3) accumulations of occupational deposits within rockshelters and shallow caves. These three kinds of sites share, with only very infrequent exceptions, a number of characteristics which throw light on their lack of cultural associations. They appear to lack habitation features such as house floors, masonry or adobe structures, and traits of this nature.* The fire hearths and storage pits which can sometimes be recognized at the sites lack significant numbers of associated artifacts. The sites have not yielded recognizable living surfaces. The few interments which have been discovered include no burial goods, or else insignificant amounts of these materials. And finally, the rate of debris and soil accumulation at the sites, as estimated by the available radiocarbon age calculations, was extremely slow with normally less than one foot of debris added per millennium. The end result is that practically no cultural associations between artifacts have been recognized. Without them, it is not possible to isolate groups of artifacts into components. It is even difficult to determine the approximate contemporaneity of artifacts in the stratigraphic columns.

It has been common for some local archeologists to assume that since a group of artifacts is present in the same geologic stratum or, worse, in the same arbitrary excavation level, they reflect a single occupation. But this is neither proof of the coevality of the artifacts nor of any close contextual

* This "lack" may result partially from the excavation techniques which have been employed, and from the lack of visually contrasting soils. Most of the Texas excavations have been of the *sondage* type, which strives first for vertical distinctions in the occurrence of artifact forms and only secondarily for feature recognition.

relationship between them in a cultural sense. The presence of distinct natural strata in sites can be quite deceptive, for the artifacts contained therein are not necessarily in cultural association with one another. In many sites which were apparently occupied intermittently by small groups of people through many millennia it is to be expected that refuse deposited at any particular time will become mixed with debris from other occupations, earlier, later, or both. If the occupying people have somewhat different artifact tool-kits, it is easy to see that a considerable variety in artifact form may end up in a single stratum or excavation level of a site. These artifacts do not represent one culture unit.

Binford (1964: 431) cautions against interpreting artifacts found in stratigraphic association as if they were one component. He makes a clear distinction between sites exhibiting primary depositional context and those showing secondary depositional context like the sites of central and southwestern Texas. The first type has not been altered in its formal properties, while the second type of site has soils, features, and artifacts that have been spatially altered through physical movement or deletion from original loci. Binford further states that "a single locus may be sequentially occupied by social units of different sociocultural or sociopolitical units, adding to the complexity of the culture history of the site" (p. 432).

The available ethnographic data for central Texas and areas bordering on southwestern Texas (there are few data for southwestern Texas itself) present a picture of numerous bands of Restricted or Central Based Wanderers, in terms of the Beardsley classification of community patterns (Beardsley and others 1956). These bands of Tonkawa and Coahuiltecans were nonhorticultural food collectors without stability of settlement. The ethnographic accounts of these bands are few and quite incomplete, coming largely from scattered Spanish governmental and missionary records dating to the late sixteenth, seventeenth, and eighteenth centuries. Yet three things are made clear by the available descriptions. The occupants of central Texas, where the data are most complete, moved their camp sites readily, often traveled for distances up to hundreds of miles to take advantage of special food supplies, and probably reoccupied old habitation sites. Furthermore, there are indications that the bands were not strictly territorial and that many different groups of people utilized a given area in certain seasons.

If the semi-wandering habits of local peoples in Spanish colonial times are at all characteristic of the prehistoric inhabitants of central and southwestern Texas, then there is no support for the assumption that approximately coeval artifacts (employing here the very broad limits of the idea of coevality used by prehistorians) from a site stratum are the relics of one group. They may have been produced by several communities of people who used the site periodically, as is recognized by Taylor (1948: 141):

The mere fact that some types come from a single site or geographic locality is, of itself, no proof that they should be grouped together culturally. Camp sites and cave sites and other stopping places of more or less transient peoples can conceivably preserve within a very limited space the products of not a few separate cultural and political entities.

Unjustified Unit Definitions

Previous endeavors directed toward synthesizing Texas archeology, especially in the central and southwestern regions of the state, have incorrectly interpreted the observed patterns in the spatial-temporal occurrence of artifact forms. Formalized culture units have been proposed. The establishment of named units cannot be justified, according to the criterion specifying the perception and demonstration of cultural associations. Geologic associations of the type where artifacts occur within the same stratum have been confused with true cultural associations, even though the two kinds of phenomena are distinct. What has happened is that archeologists who were trained or who have worked in areas where component recognition is easy have tried to analyze mixed middens with inappropriate conceptual tools and with very little understanding of the nature of the simple site deposits in areas like Texas. It is true that similar assemblages of artifacts can be discerned in midden deposits at more than one site, without determining associations other than stratigraphic ones, especially at simple midden sites lacking complex features. These have been erroneously considered components and have been used to define foci and other units.

For instance, E. B. Jelks (*in* Davis and Davis 1960: 58–59) states that over a period of 20 years dozens of sites were excavated in central Texas which reflected a close stratigraphic association of so-called *Perdiz* and *Scallorn* arrow points. Archeologists favored placing the two artifact forms (along with others) in a single unit. However, later excavations at a series of sites with greater depth of deposits showed a consistent difference in the vertical occurrence of the two types. There could be no justification for classifying them in the same unit, for the *Scallorn* type was earlier than *Perdiz,* as we know now, by several hundred years.

An example of how misleading a stratigraphic or geologic association of artifacts may be is the published interpretation of the Jake Martin Site (Davis and Davis 1960), now recognized as a peripheral manifestation of the Eastern Archaic. In a thin occupation zone at the Martin Site the following artifacts were found: points of the *Meserve* and *San Patrice* types, numerous expanding stem points, a few contracting stem points, a small number of straight stem points, and other tools. The interpretation of this material assemblage originally preferred, but since modified, was that the site contained only one complex, or component, since all the above specimens oc-

curred in a single recognizable occupation zone lacking indications of physical mixture. However, other studies conducted in the same area at the Scott Site (Bell 1953), the Doering Site (Wheat 1953), and the Yarbrough Site (Johnson 1962b) establish beyond a doubt that the artifact forms of the Martin Site actually come from many different time periods and many different occupations. Rather than a single component, there must have been numerous occupations at the Martin Site extending, perhaps, over a total interval of 6,000 years.

Since the rate of deposition at the sites of central and southwestern Texas was extremely slow, mixture like that described at the Martin Site should be expected. Dehortation against over-simple interpretation of artifacts found in stratigraphic association is as appropriate for the areas to be studied here as it is for the Martin Site.

As a good illustration of unjustified unit definition, J. Charles Kelley published two studies (1947a, 1947b) which professed to define foci in central Texas. Following Midwestern terminology, Kelley named (among other units) an Edwards Plateau Aspect for central Texas with three foci: Clear Fork, Round Rock, and Uvalde. For the Round Rock focus Kelley listed the following as diagnostics: flat, side-notched pebbles, spike-like blades, and three dart point types. He distinguished the Clear Fork Focus by the presence of gouges and three other dart point types. The Uvalde Focus, the definition of which was added to later (Kelley 1948), possessed shaft-straighteners and another three dart point forms. In all fairness, Kelley made plain that he was aware that his definitions were not complete, but the point made here is that his foci simply represent imprecise areal and temporal patterns in the distributions of artifact forms, not archeological units in the usual sense. None of his foci is defined through a careful study of cultural associations in sites. Rather, geologic or stratigraphic associations constitute the foundation for his conclusions. And here the error was committed, for recent excavations in central Texas and to the west (Shafer 1963; Johnson 1964) have demonstrated that several of Kelley's dart point forms, which he placed originally in one focus, have separate temporal distributions which do not overlap; they were clearly used by distinct groups of people.

There is little to be gained by reviewing all the archeological units which have been proposed for central and southwestern Texas as they all share the deficiencies of the ones described above. General reviews of southwestern Texas can be found in Epstein (1963: 4–7) and Johnson (1964: 10–11). The principal unit names are Big Bend Aspect (Kelley and others 1940; Kelley 1957) with its Pecos River, Chisos, and Livermore foci; and the Uvalde Focus of the Edwards Plateau Aspect (Kelley 1947a, 1947b). Central Texas is provided with a plethora of unit names ranging from the Gladwin terminology of

E. B. Sayles (1935) (Central Texas Root, Abilene Branch, Brazos River Phase, etc.), to the Midwestern labels of J. Charles Kelley (1947a) (Edwards Plateau and Central Texas aspects with numerous foci); the central Texas terminology is ably reviewed by Dee Ann Story (as Suhm 1960). The insistence here on the invalidity of the Texas archeological units is not entirely new, since the authors of the *Handbook of Texas Archeology* (Suhm and others 1954: 102–117) reject the foci for Kelley's two central Texas aspects, although the aspects themselves are retained.

The overhasty, ill-founded formulation of culture units is not peculiar to Texas. The criticisms enumerated above can be leveled at some of Richard S. MacNeish's phase definitions in Tamaulipas State, Mexico, especially in the case of the Nogales and Almagre phases. In his important archeological study of Tamaulipas, MacNeish (1958) fails to present conclusive or convincing evidence to show that the artifact forms included in the above archeological units actually represent the remains of recognizable groups of people. Cultural associations are lacking. MacNeish, like Kelley, is only able to demonstrate gross temporal changes in archeological traits. These are quite important, but to formalize these temporal variations as a sequence of distinct phases (MacNeish 1958: 198) is not supported by the data.

* * *

In sum, archeological units can be recognized in relatively complex sites where people conveniently built houses, included artifacts with burials, and in other ways thoughtfully aided archeologists trying to identify single occupational components. In simple midden sites, particularly those lacking hearths, burials with associated goods, houses, burial mounds, etc., clear cases of cultural association can be quite rare. Given the physical conditions which hinder the discovery of cultural associations in the Texas sites, as well as the behavior of the early historic peoples of the region, it is understandable that archeological culture units such as phases cannot now be defined. This should not necessarily be taken as an indication of an utter lack of cultural associations in the area. However, by the very nature of the site deposits it is unlikely that a sufficient number of associations will soon be found to justify unit definition.

Culture-historical integration of the Texas data can and will be achieved, but not in the usually conceived archeological units. Close contextual associations between artifacts (which make it possible to recognize single site components) are absolutely essential for the organization of data into greater units such as phases. The study of midden deposits lacking cultural associations should be conceived as a field of research with analytic problems all its own. The remainder of the paper will be dedicated primarily to establishing an alternative method to accomplish culture-historical integration.

Site Selection and Periodization

For the statistical study to be successful, it is necessary to select the sites which will be most suitable for the comparative analysis. Several factors have to be considered in detail. To accomplish culture-historical analysis with a body of archeological materials, three dimensions must be integrated: form, space, and time. This section will be concerned with the dimension of time. Since separate components cannot be recognized in the archeological sites of central and southwestern Texas, the process of achieving temporal correlation and collection seriation is not an easy one. One question is just *what* is going to be correlated and seriated? Obviously, site components cannot be correlated since none is known at this time. Only strata and arbitrary excavation levels can be handled in this way. Therefore, the entities which will be dated are not artifact assemblages of single peoples. They are, instead, stratum collections which possibly represent the commingled tools of several more or less discrete groups. Be this as it may, if correlation is accomplished accurately, it should be possible to assign specific artifacts (the tools of an undetermined number of communities) to a given area and span of time. These artifact forms can be described qualitatively and quantitatively, and can be compared with other such bodies of data.

Regrettably, the radiocarbon age calculations which can be applied to central and southwestern Texas are not sufficiently consistent, even in single stratigraphic columns, to be of much help for correlating strata. Two examples will show this inconsistency quite well. The dates from the Levi Rockshelter (Alexander 1963: 513), in series from top to bottom, are as follows:

5400 B.C. (± 150 years)—highest
4800 B.C. (± 150 years)
7350 B.C. (± 160 years)
8050 B.C. (± 175 years)—deepest

Clearly, the two top dates are inconsistent with their vertical positions in the deposits. The series of assays from the Kyle rockshelter (Jelks 1962: 97) shows similar inconsistencies.

A.D. 1561 (± 130 years)—highest
A.D. 1276 (± 150 years)
A.D. 1291 (± 150 years)
A.D. 561 (± 150 years)
A.D. 971 (± 170 years)
A.D. 801 (± 150 years)—deepest

Further discrepancies can be seen in the list of radiocarbon dates given in Appendix I. Three factors are thought to be responsible for this variance. First, the calculations were run by different laboratories using dating techniques which may not produce comparable results.* This could explain some of the divergencies of assays produced by different processes. Second, the association of the dated materials with their deposits is far from clear in many instances. And third, charcoal, shell, and bone which produced the dates may be subject in certain cases to the same kind of mixture as artifacts, and may not be representative of the strata from which they were collected. Another correlation technique will have to be used to determine the contemporaneity of strata or levels, and to assign them to comparable time periods.

Relative Dating

As Patterson (1963:390) has shown, in the absence of a reliable or consistent series of calendrical dates, the burden of establishing the coevality of strata or levels from several sites must be borne by techniques of relative dating. Relative dating can be achieved by employing one of three techniques. First, in certain instances it is possible to recognize a similar succession of geologic events at sites, and to correlate strata by placing them temporally before, during, or after these events. Second, in other cases excavation units can be assigned to specific periods by establishing teleconnections—by recognizing trade objects which have been dated elsewhere. Third and last, similarities in the content of excavation units can form the foundation for temporal correlation.

The first method cannot be followed in central and southwestern Texas. Most of the sites show no recognizable sequence of discrete geologic events. In part, this is due to the usual occurrence of the sites in situations where climatic fluctuations would not strongly influence their internal deposits in significant ways. Only one of the sites studied here, the Devil's Mouth Site of Val Verde County, has deep alluvial and aeolian deposits which reflect these kinds of changes. But the recognition of discrete geologic events at one site is of no advantage if the same events cannot be identified at others. On the other hand, the fact that successions of geologic events have not been recognized may be due in large part to the probably uniform and consistent climate of central and southwestern Texas during the Holocene, the geologic epoch to which most of the collections are confined. Only a few studies exist which have tried to reconstruct the local Holocene climatic sequence (*e.g.*,

* The Radiocarbon Dating Laboratory of The University of Texas produces dates with the liquid scintillation counting of benzene. Humble Oil and Refining Company employs the CO_2 method with proportional counter.

Graham and Heimsch 1960, Johnson 1963, Halfsten 1961), but their tentative findings disclose no major climatic shifts in post-Pleistocene times.

The second method, whereby trade objects are used as indexes of coevality, likewise cannot be used. With stone artifacts it is difficult to recognize trade objects without careful lithological analysis, and none has been attempted with the Texas artifacts. At certain sites it is possible to recognize a few lithic tools which are identical to artifact forms which are very abundant at other sites. Yet it is now impossible to show that these specimens were manufactured in one area and traded into another.

The present endeavor directed toward correlation and periodization will have to be based on the remaining (third) method: the recognition of similarities in the artifactual content of the strata being compared. The most common procedure is to cross-date strata on the basis of general typological similarities. When the same forms occur together in strata from several sites, then the strata are placed within the same period. A further condition is usually set, that the same types occur in similar frequencies. The "type-frequency" seriation technique, though it often is used with surface collections, is one application of this method and has been used repeatedly in the studies of Ford (1949), Bordes (1950), and the time analyses of Robinson (1951) and Brainerd (1951), Meighan (1959), Jelinek (1960, 1962), and others.

All the type-frequency seriation techniques share one serious limitation. The entire geographic area where they are applied must exhibit basically the same material culture, and any changes which occurred must have taken place at approximately the same time over the whole area. The Texas sites immediately rule out the possible use of any of these seriation techniques. The area which will be studied here stretches some 350 miles from east to west and is not culturally uniform. There are many artifact forms which have strictly local distributions and do not characterize the whole region. The observed differences, therefore, are not solely a reflection of temporal fluctuations in artifact forms, but are also due to local or regional differences in the occurrence of forms. Since the prerequisite for type-frequency seriation is geographic uniformity, the artifact collections from central and southwestern Texas cannot be seriated by this technique.

The Period Maker Correlation Technique

With the elimination of the type-frequency seriation technique, only one relative dating procedure remains. This consists of correlating synchronously by recognizing single artifact forms which cross-cut site columns at specific times, having ideally spread or diffused at a relatively rapid pace. This technique is similar to the *horizon style* correlation technique, which has been concisely reviewed by Rowe (1959), and involves the study of individual

features of artifact design. Commonly the horizon style concept has been used with ceramic types, and harks back at least to the early studies of Max Uhle (1913) in the Andean area, and was formalized by Kroeber (1944: 108–111). The way in which the stylistic attributes combine constitutes the distinct artifact style. According to Willey and Phillips (1958: 32), the horizon style

> . . . may roughly be defined as a specialized cultural continuum represented by the wide distribution of a recognizable art style. On the assumption of historical uniqueness of stylistic pattern, coupled with the further assumption that styles normally change with considerable rapidity, the temporal dimension is theoretically reduced to a point where the horizon style becomes useful in equating phases or larger units of culture in time that are widely separated in space.

There is no reason why a similar method should not be used for correlating lithic sites in the present study. The local artifacts which are sensitive to this kind of treatment are the projectile points. Numerous artifact sequences have been recognized at Texas sites, and it has been possible to plot the vertical occurrence of the lithic artifact forms. When these profiles are examined, it is always the projectile points (usually their bases or stems) which show the greatest elaboration and variability, and the most marked differences in stratigraphic occurrence. Other artifact forms, such as knife or scraper styles, often have relatively uniform vertical distributions and are unsuitable for delimiting short depositional, and hence temporal, intervals. Even the forms which do have a brief life span are often limited in their geographic range, and do not usually occur at widely separated sites. Thus, projectile point forms are most useful for correlation purposes, since they frequently have limited temporal, and wide areal, distributions. This correlation technique will be followed in central and southwestern Texas where the sites show a basically similar, homotaxical sequence of projectile point base forms (see Figs. 4–11), although there are some areal differences. In spite of the fact that the two regions are discrete natural areas, contact between them occurred and ideas such as base forms crossed ecological boundaries.

There is nothing new in the application here of this correlation technique. It has been used repeatedly with apparently good results, particularly with non-ceramic archeological sites. One of the best applications is Melvin L. Fowler's correlation of strata from four important sites in the eastern United States: Modoc Rockshelter, the Read Site, the Parrish Village Site, and the Carlson-Annis Mound (Fowler 1957, 1959). Qualitative and quantitative similarities in projectile point forms were used as a basis for inter-site correlations.

I hesitate to call the base forms horizon styles. For one thing, they occur on utilitarian objects and not art media in the strict sense. Further, their

periods of popularity were clearly much longer than that of ceramic styles discussed by Rowe and by Willey and Phillips. With these differences in mind, they shall be called, simply, *period markers*. The *horizon* label is hardly appropriate, since it implies a very brief interval of time, whereas the popularity of the period markers selected here represents broad time intervals.

The period marker correlation technique should be applied in this way. First, an accurate determination is made of the vertical succession of base forms for each archeological site. The relative frequencies of each form are calculated and plotted by level or stratum. After the sequences and the frequencies have been established, note is made of the forms which have specific zones of clear dominance. These forms are selected as period markers because they delineate comparatively short vertical intervals in the deposits, and by inference, relatively discrete spans of time. When the forms so selected occur in the same vertical positions relative to each other at several sites, they are used for cross-dating—for correlation and periodization. Strata from sites which show high frequencies of the same form are equated temporally, and named or numbered periods are established.

Since there is a smaller number of attributes in projectile point forms than, say, in decorated ceramic types, it is more likely that similar forms could develop independently in the former class. Thus it is possible that points of the same form found at different sites may be historically unrelated and, if so, this would destroy their value for purposes of inter-site correlation. Since, however, the superposition of forms is similar at numerous sites in central and southwestern Texas, the likelihood of independent invention is small.

A word or two of explanation is needed about the mention of frequencies above. The task of correlation is not so simple as it might seem. If one point form followed directly after another which it abruptly replaced in the deposits (as is *not* the case with the Texas sites), the job of relating strata from several sites into a sequence of coeval time intervals would be routine. That this is rarely the case can be seen from a cursory review of artifact type frequencies, tabulated by depth or deposit, at almost any of the Texas sites one chooses to examine. The frequency graph in the Devil's Mouth site report (Johnson 1964: 85) is a perfect example of this widely occurring phenomenon. In practically all the sites of central and southwestern Texas the artifact forms have a lens-shaped vertical distribution, and overlap each other in their occurrence.

The most common explanation of this phenomenon is that an artifact form, when first adopted, occurred at first in small numbers and gradually superseded other forms as its popularity grew. Finally, it was slowly replaced by successive styles. There can be little doubt that this is basically a correct description of the span of a particular form, but I doubt very seriously whether the deposits from the Texas sites would ever be capable of revealing

it. The rate of accumulation was usually far too slow to record this kind of phenomenon, except in the case of long-lived types or artifact classes which could not possibly serve as period markers anyhow. The Texas site with the deepest deposits is the Devil's Mouth Site of Val Verde County, whose 36 ft.-deep terrace represents a total time span of seven or eight millennia. Yet even at this site the rate of vertical accumulation was probably in the neighborhood of only one foot per 200 years (see Johnson 1964: Figs. 5, 25).

The lenticular vertical distribution of the artifact forms in the comparatively shallow Texas sites can best be explained by citing another kind of phenomenon, the mixing of artifacts from different occupations. With sites whose deposits built upward at a very slow rate (as is definitely the case for the sites from central and southwestern Texas), a relatively large amount of mixing would inevitably occur. Causative mechanisms are legion. They include activities of the indigenes such as pit digging, trampling of current artifacts into deposits containing earlier forms, and such. Also, non-human agencies such as wind and water erosion, the burrowing of rodents, tree root activity in wooded areas, and like causes operated to displace the artifacts.

In spite of this sort of depositional situation, there is no need to despair of using period markers for synchronic correlation. It is possible to recognize the highly mixed deposits and to exclude them from consideration by assigning to a specific period only the strata or levels of a column which contain the maximum frequency of the appropriate indicator (artifact form). The maximum of a form is its highest frequency calculated relative to other forms present in the same stratum. The zones falling between maxima of forms being used as period markers will, therefore, be rejected from study, since they are highly mixed.* This means that only a portion of the total artifact sample of the sites will be considered in the following analysis. Although this procedure has the effect of decreasing the sample sizes, of lowering the total number of artifacts to be studied, it can be justified since it excludes extensively mixed, and hence confused, deposits. It is advisable to control as tightly as possible the temporal dimension of artifact collections since it is important to be able to say, in certain instances, that differences in the formal and quantitative make-up of collections are not basically a function of temporal fluctuation in artifact popularity.

It should be pointed out that the use of projectile point frequencies for correlation purposes is not the same as the general "type-frequency" seriation

* It is useful to illustrate the procedure outlined here by citing cases from the actual periodization process undertaken later in the paper. Figs. 4–11 show the assignment of site deposits to periods; in them the mixed zones between period marker maxima can readily be seen. For example, approximately equal percentages of several period markers occur in strata 11 through 13 of Fig. 7; no period marker enjoys a clear dominance. Thus these deposits are considered mixed, and no period assignment is made for them.

employed by Ford (1949), Robinson (1951), and others where total collections of artifact classes (such as ceramics) are compared. In the present instance only a small number of projectile point forms (those which serve as period markers) are used for correlation, not whole point collections. Therefore, although both rely on frequency information, the use of period markers and type-frequency seriation are distinct correlation techniques.

A factor which could complicate the use of artifact form maxima as period markers is the possibility of time lag in the diffusion of a form. It is unquestionably true that all communities in an area would not accept new forms of artifacts at precisely the same instant. Therefore, might not strata from two sites synchronously equated on the basis of their possessing the maxima of the same form actually represent somewhat different time periods? Except in those instances where it can be shown that new artifact types are brought into a large region suddenly by an immigrant population, the criticism has its salient points. At the present, temporal control over the Texas data is poor and it is impossible to determine the loci of origin for the period markers and the direction of their movement as they spread over central and southwestern Texas. Reliable radiocarbon dates for many sites are necessary for this kind of accurate documentation of diffusion, and they are lacking. However, the problem of lag need not inhibit the use of period markers for synchronous correlation, because the periods defined here are very gross slices of the time continuum, not one of which likely represents less than five centuries. The kind of diffusion lag described above should have very little significance, since its effects would be obliterated by the great time span of the periods. If brief periods were being defined, its effect would be more serious.

The foregoing discussion points up an additional problem. This is, that since periods will be defined in very broad terms, the temporal dimension of the collections will be controlled for comparative purposes only in a general way. Units of accumulation from different sites which are assigned to the same period may be precisely equivalent in age, but others may overlap in time or may conceivably belong to different absolute ages within a broad period. The longer the period, the more likely the possibility that deposits from the sites assigned to it may not represent the same portions of the total period. This is a limitation of the study which cannot be overcome, and its possible influence on the outcome of the analysis will have to be kept in mind.

The Sites

Of the numerous archeological sites which have been excavated in southwestern and central Texas, a study of the sequence of their base forms produces only nine sites whose strata show the kind of segregation of forms

demanded for correlation and period definition. They extend along an approximate east-west axis from the sculptured desertland of southwestern Texas into the semi-wooded hills of the central part of the state (see map, Fig. 1). The total distance of their range is some 350 miles.

The sites are listed as follows, along with the sources used to recognize their sequence of base forms. Beginning in the west and moving eastward, they are Roark Cave (Kelly 1963: Table 1), Centipede Cave* (Epstein 1963: Tables 5 and 6), the Coontail Spin Rockshelter* (Nunley and Duffield MS: Table of Artifact Distributions), the Devil's Mouth Site* (Johnson 1964: Tables 1–4), the Wunderlich Site (Johnson 1962a: Table 1), the Oblate Rockshelter (Tunnell 1962: Tables 3 and 4), the Levi Rockshelter (Alexander 1963: Table 2), the Smith Rockshelter (Suhm 1957: 33 39), and the Kyle Rockshelter (Jelks 1962: Table 1).

The remaining archeological sites of the region are unsuitable for consideration here for one or more of a number of important reasons. Some were excavated by methods which because of their lack of rigor prohibit the recognition of distinct periods of occupation. Other sites were reported in so general a fashion that it is impossible to make the necessary distinctions in the categories of artifacts which were recovered. A third group of sites is also unsuitable, although they were excavated and reported adequately, because their deposits lack sufficient depth to show temporal differences in the occurrence of artifact forms. These habitation areas built up only a scanty amount of midden soil through many thousands of years and are extremely mixed.

The nine remaining sites meet the minimum qualifications for the analysis which will be attempted. By and large, they were excavated with enough care and have deep enough deposits so that it is possible to distinguish one or more gross time intervals in their deposits by using period markers. In addition, all excavated soil was passed through screens having a maximum mesh of one-half inch. Thus the possible problem of differential collecting does not seem significant. Second, the artifacts from these sites are published in relative detail, and are accompanied by accurate intra-site provenience information. Third, and equally important, the data from all nine sites are available for study. Eight of the sites have been published in professional archeological journals or as monographs, while the report on the excavation of the Coontail Spin Rockshelter, which is in manuscript form, was made available for examination.

Roark Cave was excavated by amateur archeologists in 1960 and 1961 (Kelly 1963). It is situated halfway between the Chisos Mountains and the mouth of the Pecos River in Brewster County, on a cliff overlooking Reagan

* Located in the Amistad Reservoir area of Val Verde County.

FIG. 1. General map of southwestern and central Texas with site locations.

Canyon, a tributary of the Rio Grande (Fig. 1). The cave might better be termed a rockshelter, since it extends only 43 feet into the cliff face, and is 73 feet wide. Only those materials excavated in the cave itself (as opposed to the talus slope) will be included in this study; they were acquired from deposits which vary in depth from one to four feet. The area surrounding Roark Cave is rough, dissected desert land with scattered thorny bushes, spine-covered succulents, and hardy arid-land grass. The cave is perched high above the dry canyon floor, and is difficult of access. The only reliable surface water in the proximity of the site today is the Rio Grande, some five air-miles to the southeast.

Centipede Cave was excavated in 1958 by J. F. Epstein (1963). This small rockshelter is located high on the steep northern canyon wall of the Rio Grande near the ghost town of Shumla in Val Verde County (Fig. 1). The mouth of the rockshelter is 44 feet wide, and the maximum front-to-back depth is 37 feet. The deposits reach a maximum thickness of five feet. Although the local desert is divided into valleys and undulating uplands, the general relief is not so marked as that near Roark Cave. The Rio Grande is the single permanent source of water in the immediate locality.

Coontail Spin Rockshelter was excavated in 1962 (Nunley and Duffield MS). It is located in Val Verde County, on a steep bluff on the north side of the Rio Grande eight miles below the mouth of the Pecos River(Fig. 1). The rockshelter is approximately 300 feet wide and extends back into the canyon wall for a maximum distance of 40 feet. The depth of the interior deposits is about 13 feet.

The Devil's Mouth Site was tested in 1959, and more extensive excavation was undertaken in 1961 and 1962 (Johnson 1961, 1964). The site is in Val Verde County approximately 15 miles northwest of the city of Del Rio (Fig. 1). It is an exposed habitation site on and within an alluvial terrace remnant of the Rio Grande, and is situated directly northwest of the mouth of the Devil's River. The horizontal dimensions of the site have not been determined, since much of the occupation area is deeply buried and cannot be observed from the surface. The site attains a maximum depth of 36 feet. The local setting is typically desert, but the terrain is definitely less rugged than it is farther upstream in the vicinity of Centipede Cave and the Coontail Spin Rockshelter. Although the Devil's Mouth Site is only 20 miles down the Rio Grande from Coontail Spin, vegetation is more abundant locally than farther upstream and grasses grow more profusely. The Devil's River and Rio Grande provide abundant water supplies.

The Wunderlich Site of central Texas was excavated in 1960 (Johnson 1962a). It is a small habitation site on a low alluvial terrace of Rebecca Creek, one of the minor tributaries of the Guadalupe River. The site is located approximately 4,000 feet west of the mouth of Rebecca Creek, within

the boundaries of Comal County (Fig. 1). The Wunderlich Site is one of the many "burned rock middens" of central Texas, so called because of the large accumulations of firecracked limestone which extend through the occupation deposits. The exact dimensions of the Wunderlich Site have not been determined, but it is possible to estimate a total surface area of some 1,500 square feet. The midden soil is shallow and reaches an average depth of only four feet. The environmental setting is quite different from that of Val Verde and Brewster counties to the west. This is a country of low hills, many small streams, and an abundance of springs which flow throughout the year.

The Oblate Rockshelter was excavated in 1959 and 1960 (Tunnell 1962). It opens onto a small unnamed tributary of the Guadalupe River in Comal County, central Texas (Fig. 1). The site consists of a stratified midden deposit found beneath an overhanging rock ledge and extending out into a broad alluvial deposit. The precise horizontal dimensions of the whole occupation area were not determined. The rockshelter itself measures 85 feet wide and about 13 feet deep from front to back, while the depth of the midden deposits varied from three to eight feet. The Oblate Rockshelter occurs in the same general environment as the Wunderlich Site.

The Levi Rockshelter of Travis County, central Texas, was excavated by archeology students of The University of Texas in 1959 and 1960 (Alexander 1963). The rockshelter is in the northern wall of Lick Creek Canyon, a tributary of the Pedernales River (Fig.1). The mouth of the shelter is approximately 120 feet wide, and the overhang measures 15 feet from front to back. The interior deposits average nine feet in depth. The eastern edge of the rolling Edwards Plateau where the Levi Rockshelter is located has many spring-fed streams, and stunted forest of oak and juniper. Lick Creek is nourished by springs and flows constantly.

The Smith Rockshelter was dug by students of The University of Texas in 1954 and 1955 (Suhm 1957). The site is located six miles southeast of Austin, Travis County, in a low rocky bluff overlooking Onion Creek, a tributary stream of the Colorado River (Fig. 1). The mouth of the site measures 130 feet wide, and the overhanging roof extends 25 feet outward. The deposits which show evidence of occupation attain a maximum depth of eight feet. The area around the rockshelter is furnished with a reliable source of water, since there are several spring-fed creeks and the Colorado River itself. The Smith Rockshelter is located in the gently rolling prairie country which borders the Edwards Plateau on the east and south. The margin of the plateau is but 10 miles to the west of the site.

The Kyle Rockshelter, the last of the nine sites, was excavated by professional and amateur archeologists in 1959 and 1960 (Jelks 1962). It is located in Hill County, toward the northern limits of central Texas (Fig. 1). The

shelter is situated in the rocky wall of a short, normally dry tributary of the Brazos River. The Kyle Rockshelter measures about 90 feet in length by 33 feet in width, and its deposits reach a depth of approximately 12 feet. The nearest permanent water was the Brazos River, whose channel ran some 2,500 feet from the site before it was impounded to form an artificial lake. When the water table was higher than it is at the present time, there were active springs within the canyon. Trees, shrubs, and grasses grow in the canyon proper, but the rolling upland terrain was covered with thick prairie grass before recent over-grazing. The Kyle Site is located far to the north of the other central Texas sites listed above, outside the limits of the Edwards Plateau proper.

The Period Markers

The projectile point base forms which serve as period markers for the foregoing sites have very little in common with general artifact types. Only the traits which help describe the base itself are used in their definition. The shape of the artifact above the base is immaterial for this classification, as are size, surface characteristics, and modes of manufacture. The diagnostic form of each base was produced by a pattern knapping treatment; some bases were made concave, some were narrowed and sharpened to a point, while others were formed by deep corner notches. Whatever the treatment, the resultant forms are far from random. It seems that the bases were a discrete realm of expression for the manufacturer. While some of the formal variation is doubtless linked to different hafting techniques, there was probably some purely stylistic modification as well. For whatever reasons, the projectile point bases show considerable variation through time, and function well as period markers, as can be seen in their superposition in Figs. 4–11. Other attributes of the projectile points are not temporally significant; for instance, the same blade and barb forms often occur together with basal forms of different periods.

For ease of reference, the 11 basal forms which are recognized as period markers are labeled alphabetically in approximate sequence from most ancient to most recent. Table 1 provides the published type names for each period marker, and a list of the sites where they are recognized. Outline drawings of all period markers appear in Fig. 2

A has contracting, convex lateral edges and a pointed base. There is no indentation of the lateral edges to form a stem.

B is a base form with parallel, or nearly parallel, lateral edges and markedly concave basal edge.

C has a rectanguloid stem formed by deep corner notches; the basal edge is approximately straight.

TABLE 1

Published designations for period markers and their occurrence

Base Form:	Published Designations:	Sites:
Period Marker A	Lerma	Levi (Alexander 1963: 516)
		Devil's Mouth (Johnson 1964: 52)
Period Marker B	Plainview-Angostura	Levi (Alexander 1963: 513–514)
	Plainview, Golondrina var.	Devil's Mouth (Johnson 1964: 46–52)
Period Marker C	Early Barbed	Devil's Mouth (Johnson 1964: 33–34)
Period Marker D	Pandale	Roark (Kelly 1963: 208)
		Devil's Mouth (Johnson 1964: 40–42)
		Coontail Spin (Nunley and Duffield MS)
	Nolan	Wunderlich (Johnson 1962a: 25)
		Smith (Suhm 1957: 38–39)
	Travis	Wunderlich (Johnson 1962a: 27)
	Bulverde	Coontail Spin (Nunley and Duffield MS)
		Wunderlich (Johnson 1962a: 19)
		Smith (Suhm 1957: 38–39)
Period Marker E	Shumla	Roark (Kelly 1963: 208)
		Centipede (Epstein 1963: 40–41)
		Coontail Spin (Nunley and Duffield MS)
		Devil's Mouth (Johnson 1964: 42–43)
		Wunderlich (Johnson 1962a: 27)
	Almagre	Centipede (Epstein 1963: 34–36)
		Coontail Spin (Nunley and Duffield MS)
		Devil's Mouth (Johnson 1964: 30–32)
	Langtry	Roark (Kelly 1963: 205–208)
		Centipede (Epstein 1963: 36–39)
		Coontail Spin (Nunley and Duffield MS)
		Devil's Mouth (Johnson 1964: 38–39)
		Wunderlich (Johnson 1962a: 23)
Period Marker F	Pedernales	Wunderlich (Johnson 1962a: 25–27)
		Oblate (Tunnell 1962: 92–94)
		Smith (Suhm 1957: 38–39)
		Kyle (Jelks 1962: 39–40)
Period Marker G	Montell	Roark (Kelly 1963: 208–210)
		Devil's Mouth (Johnson 1964: 39–40)
		Wunderlich (Johnson 1962a: 23–25)
		Oblate (Tunnell 1962: 92)
Period Marker H	Ensor	Roark (Kelly 1963: 203)
		Centipede (Epstein 1963: 45–46)
		Coontail Spin (Nunley and Duffield MS)
		Devil's Mouth (Johnson 1964: 34–36)

TABLE 1—(Continued)

Published designations for period markers and their occurrence

Base Form:	Published Designations:	Sites:
		Wunderlich (Johnson 1962a: 21)
		Oblate (Tunnell 1962: 88)
		Smith (Suhm 1957: 38–39)
	Frio	Roark (Kelly 1963: 203)
		Centipede (Epstein 1963: 46–48)
		Devil's Mouth (Johnson 1964: 37)
		Wunderlich (Johnson 1962a: 23)
		Oblate (Tunnell 1962: 90–92)
Period Marker I	Darl	Smith (Suhm 1957: 38–39)
	Figueroa	Devil's Mouth (Johnson 1964: 36–37)
		Wunderlich (Johnson 1962a: 30; 1964: 36–37)
	Godley	Kyle (Jelks (1962: 40)
Period Marker J	Scallorn	Oblate (Tunnell 1962: 98)
		Smith (Suhm 1957: 36)
		Kyle (Jelks 1962: 27–31)
Period Marker K	Livermore	Roark (Kelly 1963: 199)
	Bonham	Centipede (Epstein 1963: 51)
	Perdiz	Roark (Kelly 1963: 199)
		Centipede (Epstein 1963: 51–52)
		Devil's Mouth (Johnson 1964: 58)
		Wunderlich (Johnson 1962a: 32)
		Oblate (Tunnell 1962: 96–98)
		Smith (Suhm 1957: 33–35)
		Kyle (Jelks 1962: 24–26)

D has a long, rectanguloid stem with parallel or slightly concave lateral edges and an approximately straight base.

E is characterized by a relatively long, pointed stem which contracts slightly toward the base. The lateral edges of the stem are straight or slightly convex, while the base is pointed, sharply rounded, or, in a few cases, straight.

F has the same general characteristics of D, with two exceptions: the rectangular stem is somewhat shorter and the base is noticeably concave.

G is an easily distinguished form. It possesses a slightly expanded stem and a deeply notched, convex base.

H shows lateral notches just above the base, which is straight to moderately concave. The corners of the base are either rounded or straight.

I is distinguished by an expanded stem produced by corner notching or lateral thinning. The short base is slightly concave or straight.

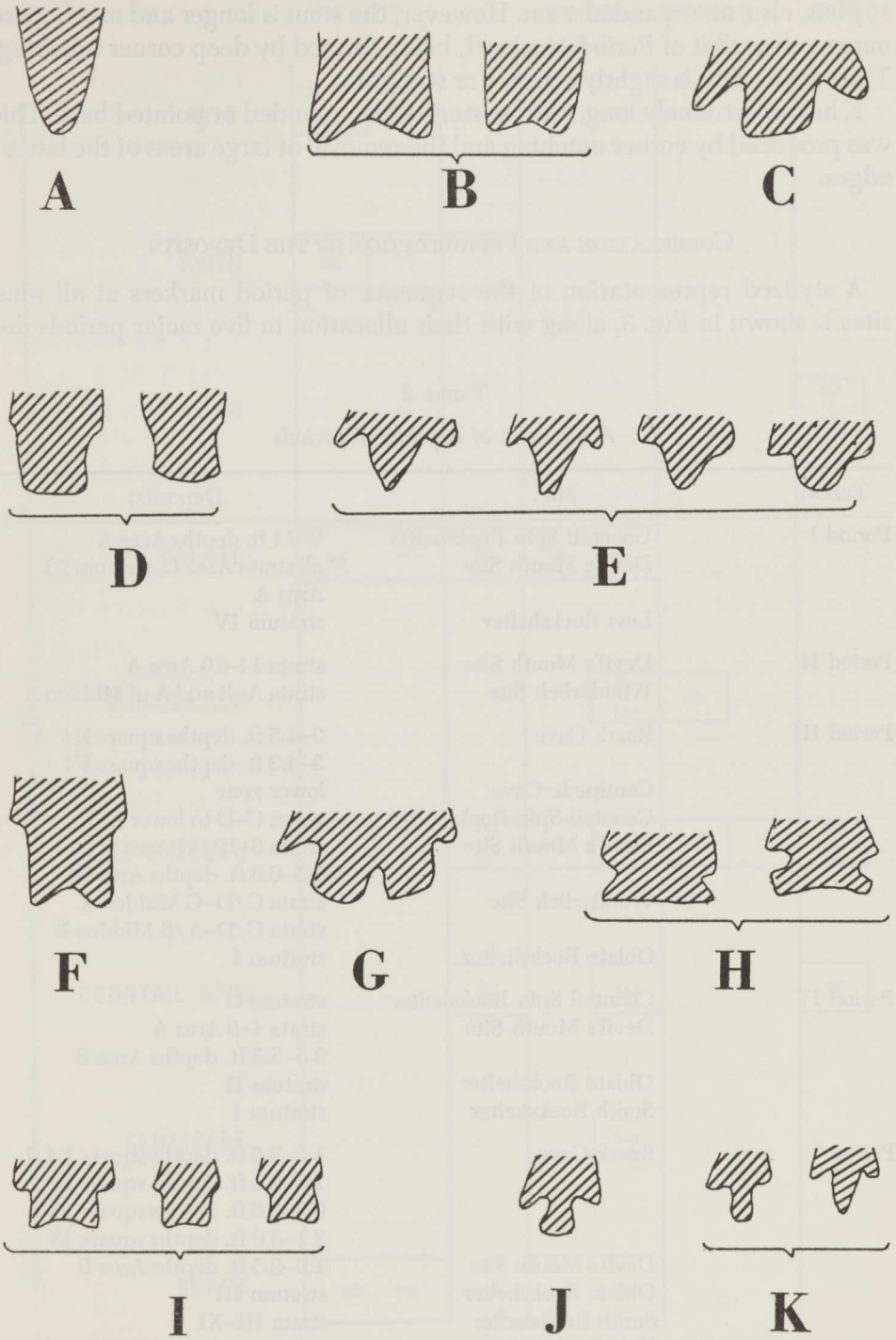


FIG. 2. Outline drawings of period markers.

J has, also, an expanded stem. However, the stem is longer and much more narrow than that of Period Marker I, being formed by deep corner notching. The narrow base is slightly concave or straight.

K has an extremely long, narrow stem with a rounded or pointed base. This was produced by corner notching and the removal of large areas of the lateral edges.

Correlation and Periodization of the Deposits

A stylized representation of the sequence of period markers at all nine sites is shown in Fig. 3, along with their allocation to five major periods de-

Table 2

Assignment of deposits to periods

Period:	Site:	Deposits:
Period I	Coontail Spin Rockshelter	9–11 ft. depths Area A
	Devil's Mouth Site	all strata Area C, stratum 23 Area A
	Levi Rockshelter	stratum IV
Period II	Devil's Mouth Site	strata 14–20 Area A
	Wunderlich Site	strata A–B and A of Midden A
Period III	Roark Cave	3–4.5 ft. depths square K4
		3–4.3 ft. depths square F4
	Centipede Cave	lower zone
	Coontail Spin Rockshelter	zones C–D to lower D
	Devil's Mouth Site	strata 6–10/11 Area A
		5.5–9.0 ft. depths Area B
	Wunderlich Site	strata C/D–C Midden A
		strata C/D–A/B Midden B
	Oblate Rockshelter	stratum I
Period IV	Coontail Spin Rockshelter	stratum C
	Devil's Mouth Site	strata 4–5 Area A
		2.5–5.5 ft. depths Area B
	Oblate Rockshelter	stratum II
	Smith Rockshelter	stratum I
Period V	Roark Cave	1.3–3.5 ft. depths square L4.5
		1.5–2.5 ft. depths square K4
		0.5–2.0 ft. depths square J5
		2.1–3.0 ft. depths square J3
	Devil's Mouth Site	1.0–2.5 ft. depths Area B
	Oblate Rockshelter	stratum III
	Smith Rockshelter	strata III–XI
	Kyle Rockshelter	strata 4 and 5

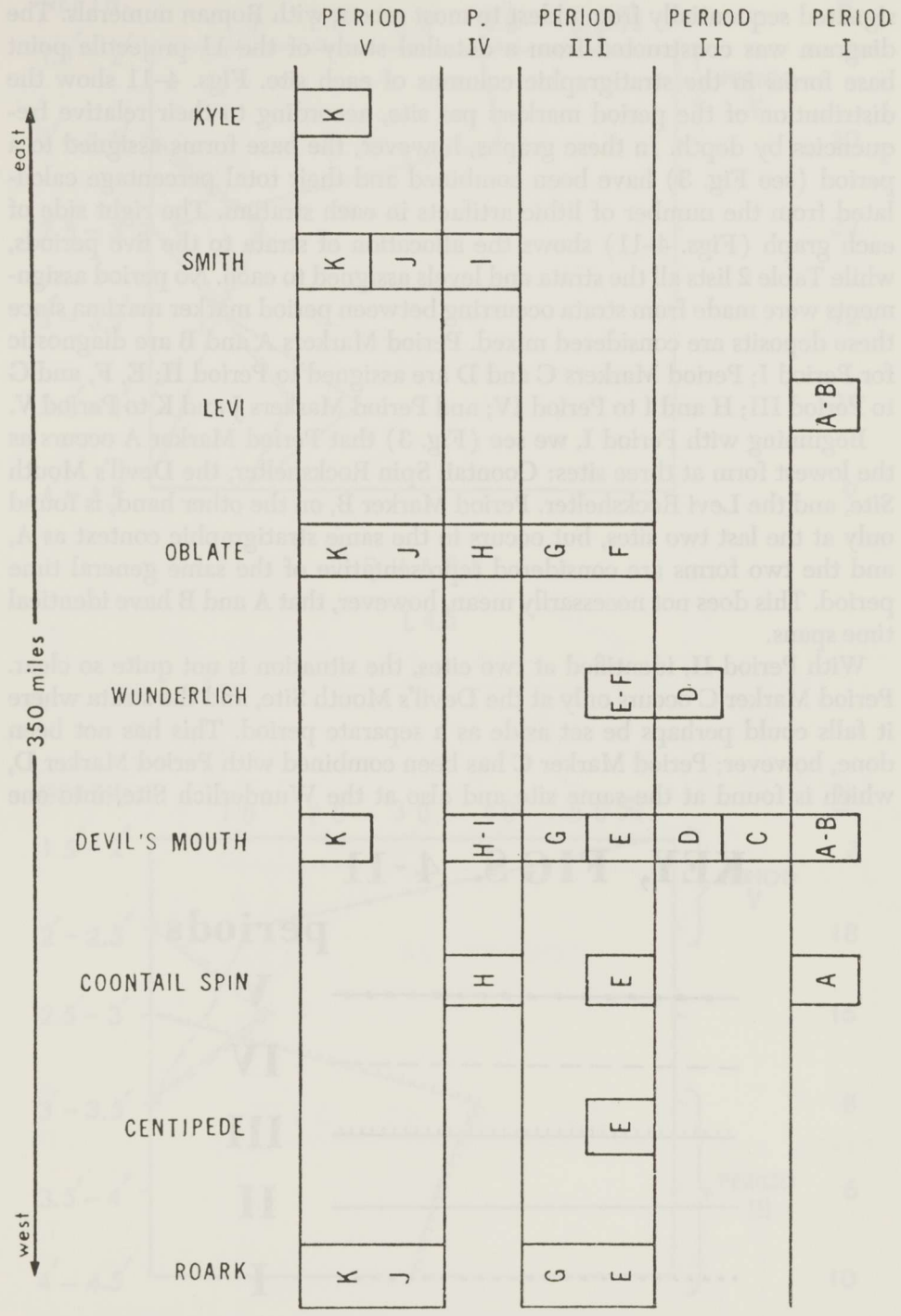
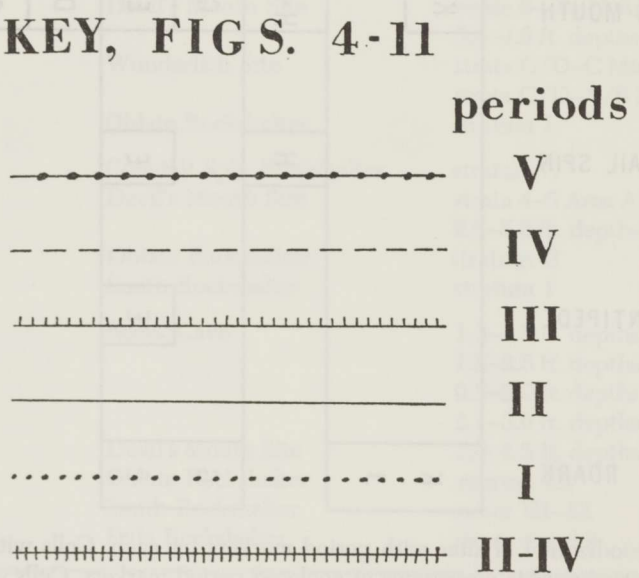


FIG. 3. Periodization of sites with period markers for each. Cells with single letters show discrete stratigraphic occurrence of enclosed period markers. Cells with two letters show mixture of the two indicated markers.

signated sequentially from oldest to most recent with Roman numerals. The diagram was constructed from a detailed study of the 11 projectile point base forms in the stratigraphic columns of each site. Figs. 4–11 show the distribution of the period markers per site, according to their relative frequencies by depth. In these graphs, however, the base forms assigned to a period (see Fig. 3) have been combined and their total percentage calculated from the number of lithic artifacts in each stratum. The right side of each graph (Figs. 4–11) shows the allocation of strata to the five periods, while Table 2 lists all the strata and levels assigned to each. No period assignments were made from strata occurring between period marker maxima since these deposits are considered mixed. Period Markers A and B are diagnostic for Period I; Period Markers C and D are assigned to Period II; E, F, and G to Period III; H and I to Period IV; and Period Markers J and K to Period V.

Beginning with Period I, we see (Fig. 3) that Period Marker A occurs as the lowest form at three sites: Coontail Spin Rockshelter, the Devil's Mouth Site, and the Levi Rockshelter. Period Marker B, on the other hand, is found only at the last two sites, but occurs in the same stratigraphic context as A, and the two forms are considered representative of the same general time period. This does not necessarily mean, however, that A and B have identical time spans.

With Period II, identified at two cites, the situation is not quite so clear. Period Marker C occurs only at the Devil's Mouth Site, and the strata where it falls could perhaps be set aside as a separate period. This has not been done, however; Period Marker C has been combined with Period Marker D, which is found at the same site and also at the Wunderlich Site, into one



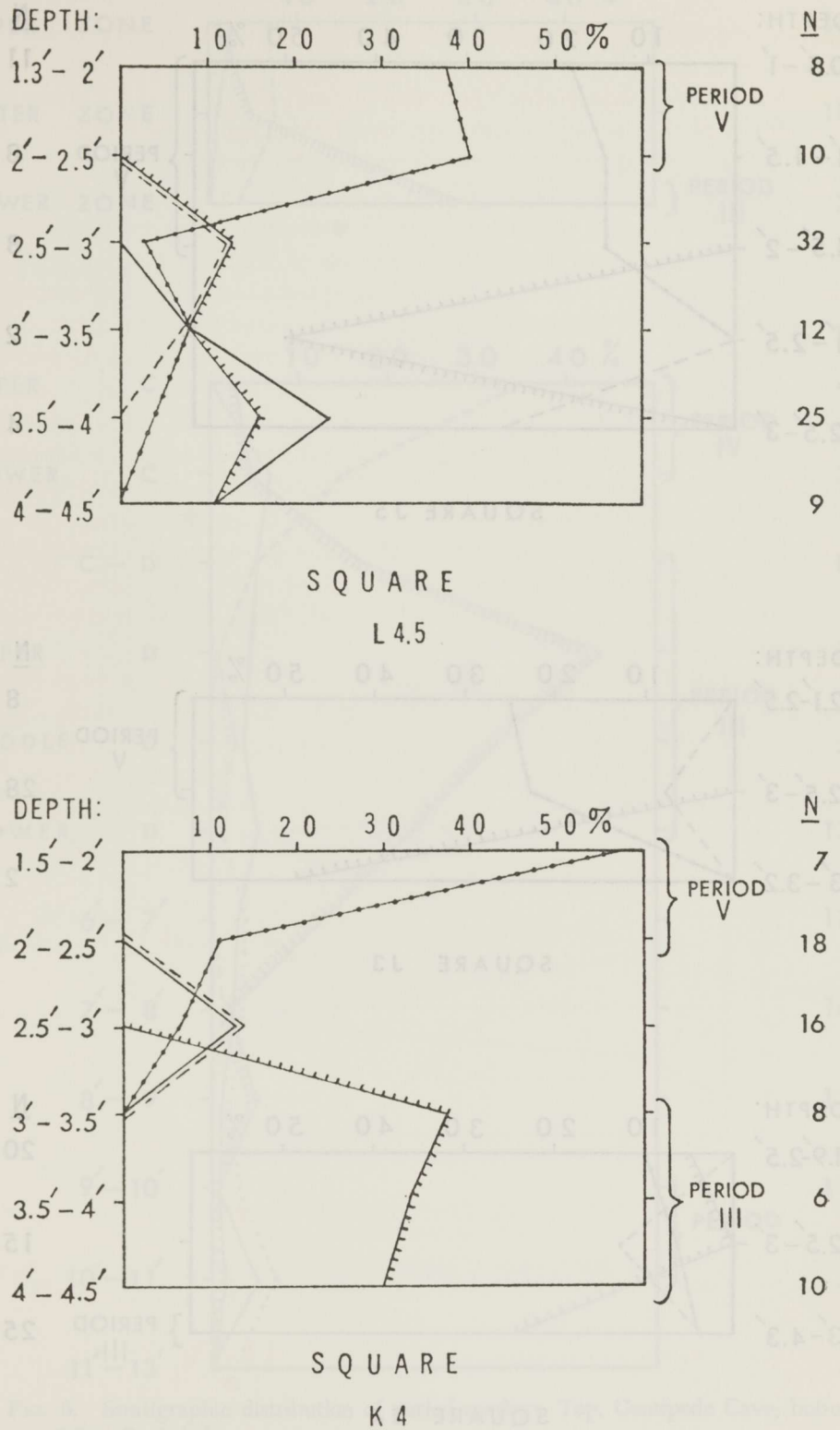


FIG. 4. Stratigraphic distribution of period markers, Roark Cave.

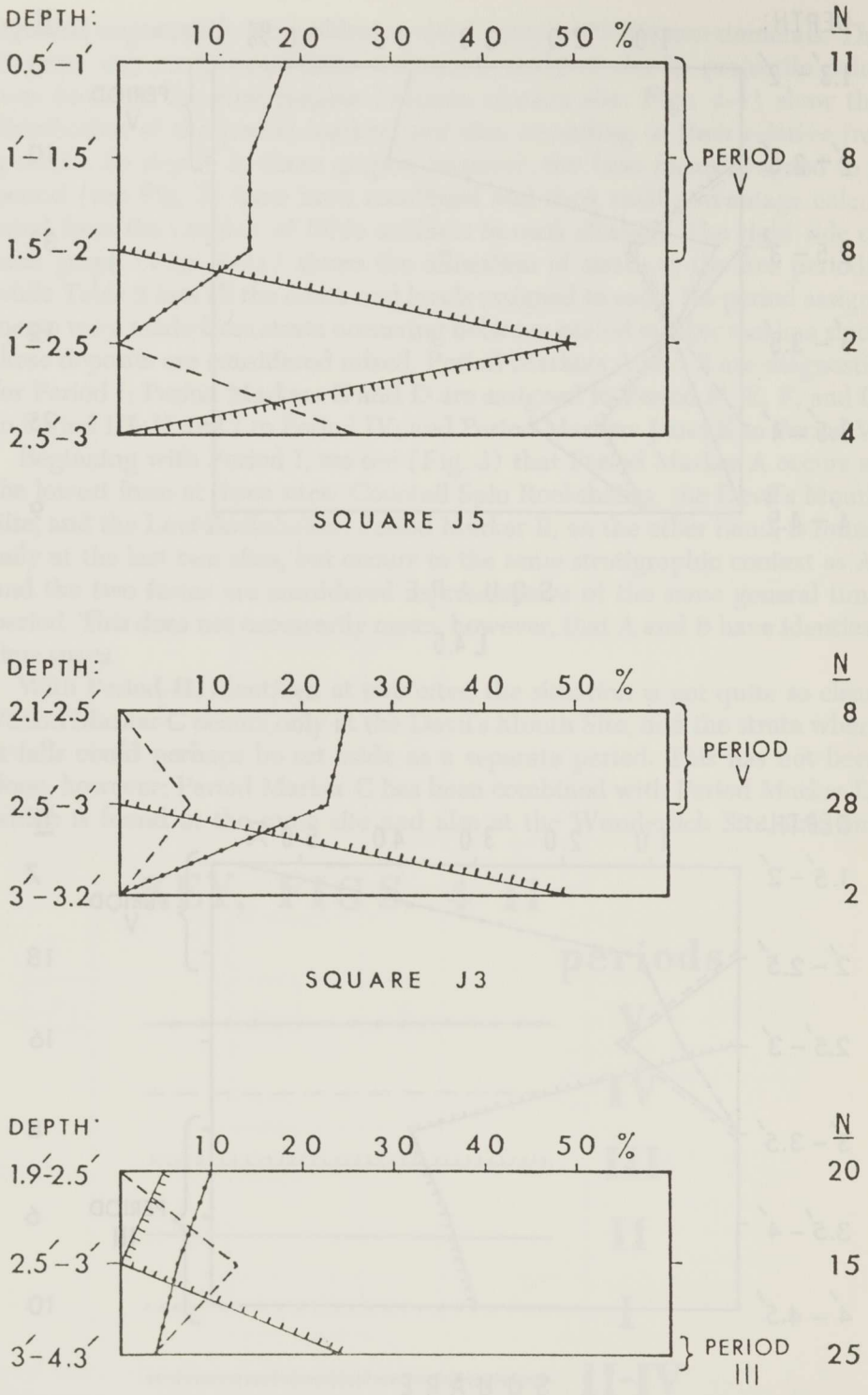


FIG. 5. Stratigraphic distribution of period markers, Roark Cave (continued).

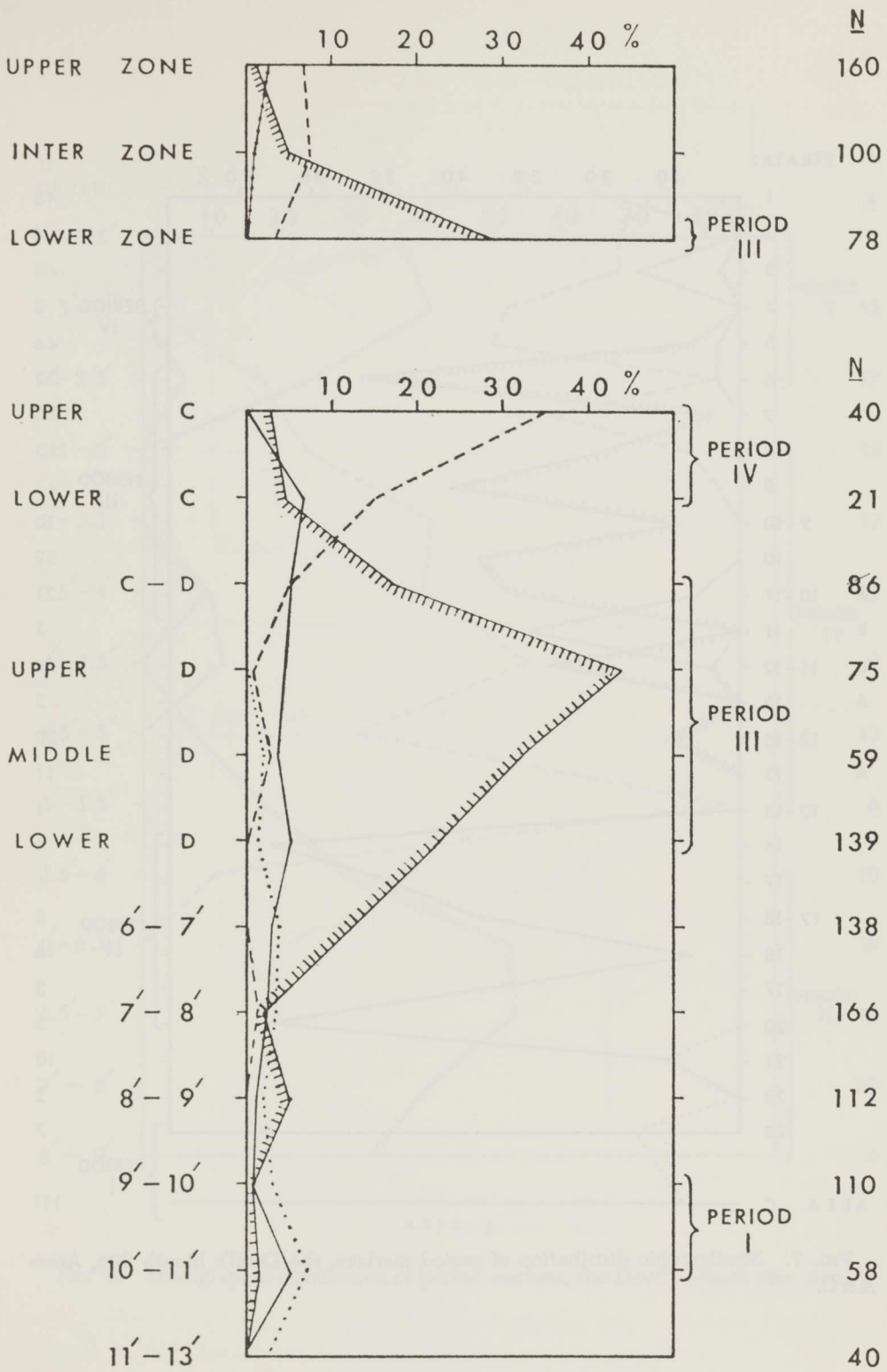


FIG. 6. Stratigraphic distribution of period markers. Top, Centipede Cave; bottom, Coontail Spin Rockshelter.

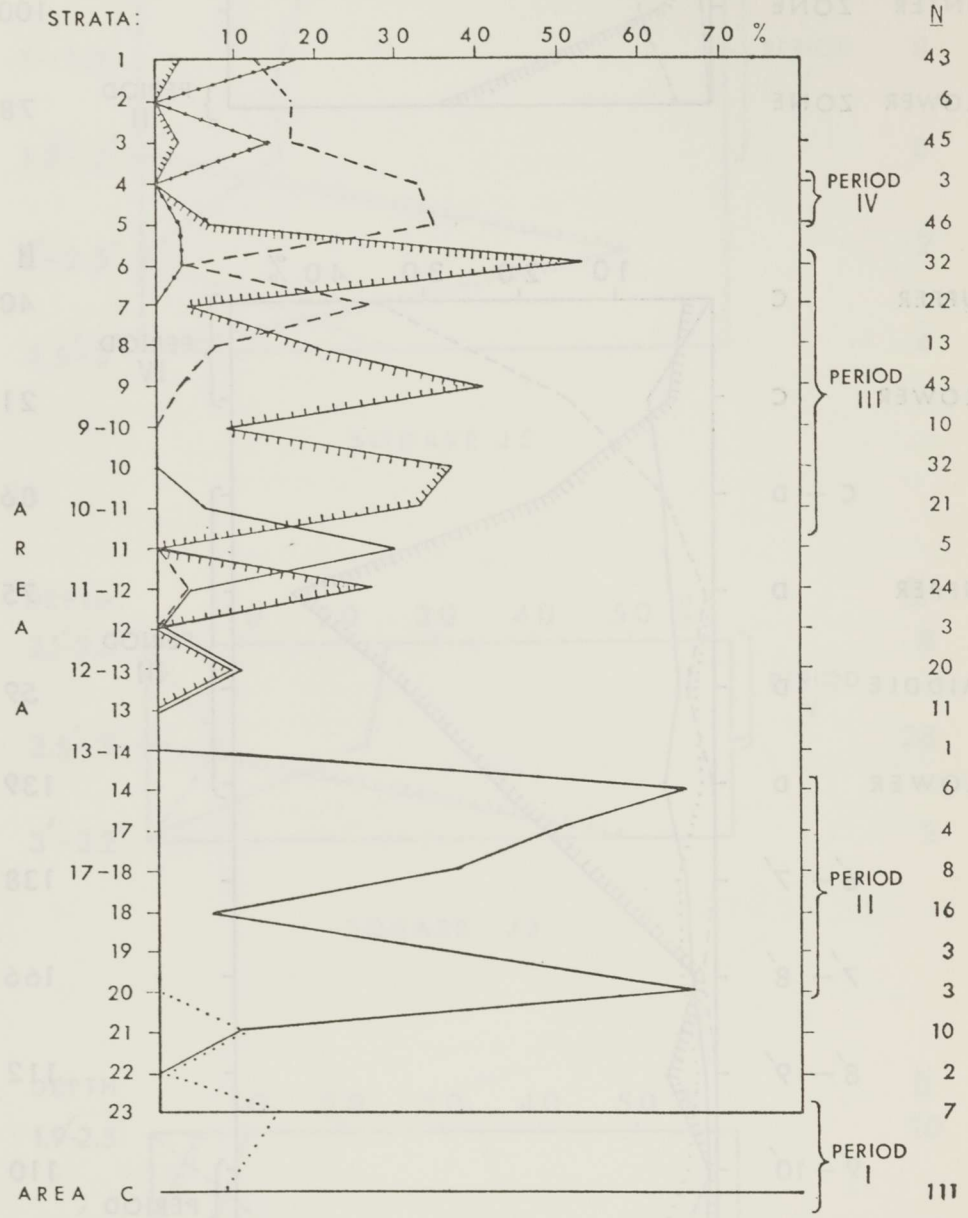


FIG. 7. Stratigraphic distribution of period markers, the Devil's Mouth Site, Areas A & C.

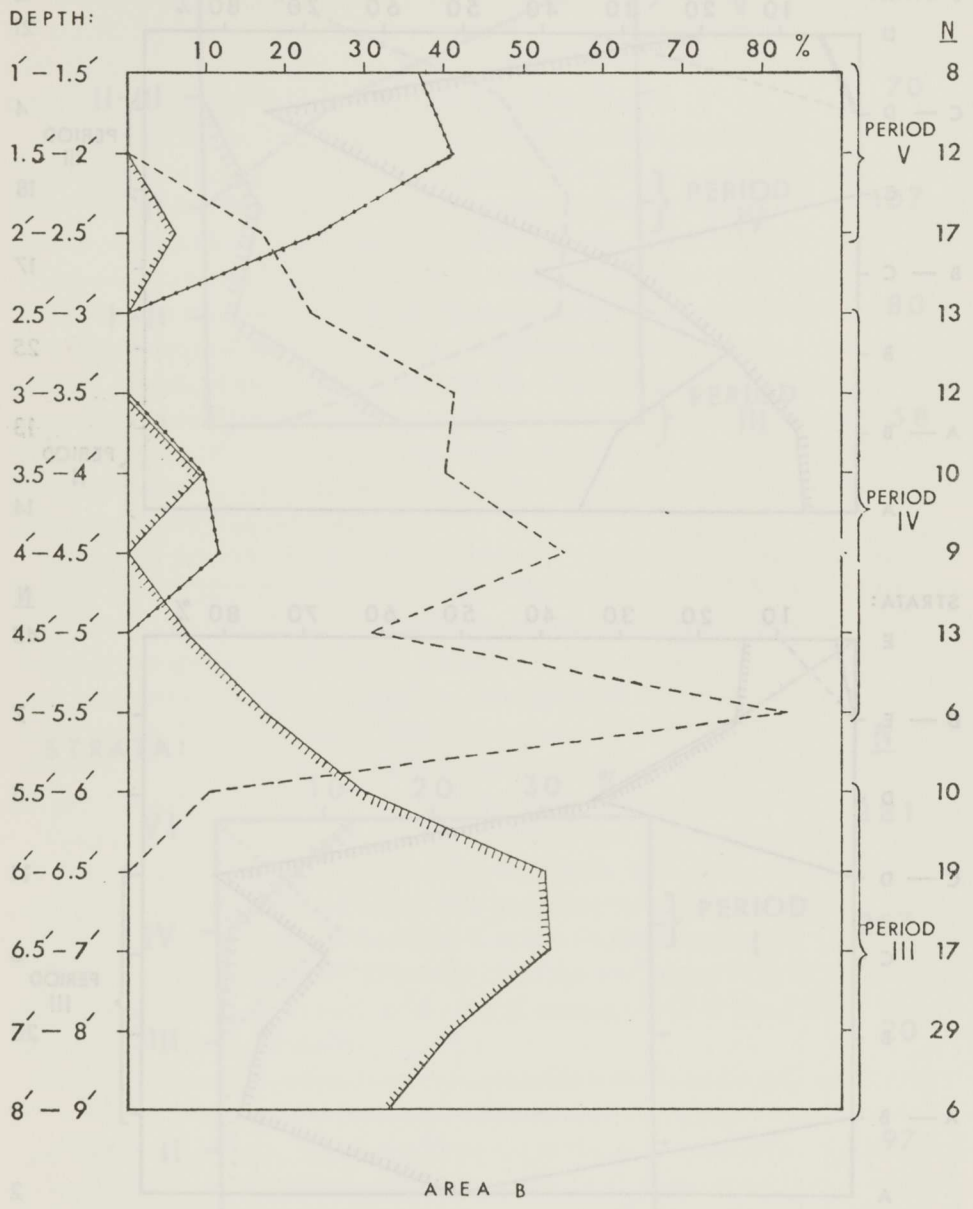


FIG. 8. Stratigraphic distribution of period markers, the Devil's Mouth Site, Area B.

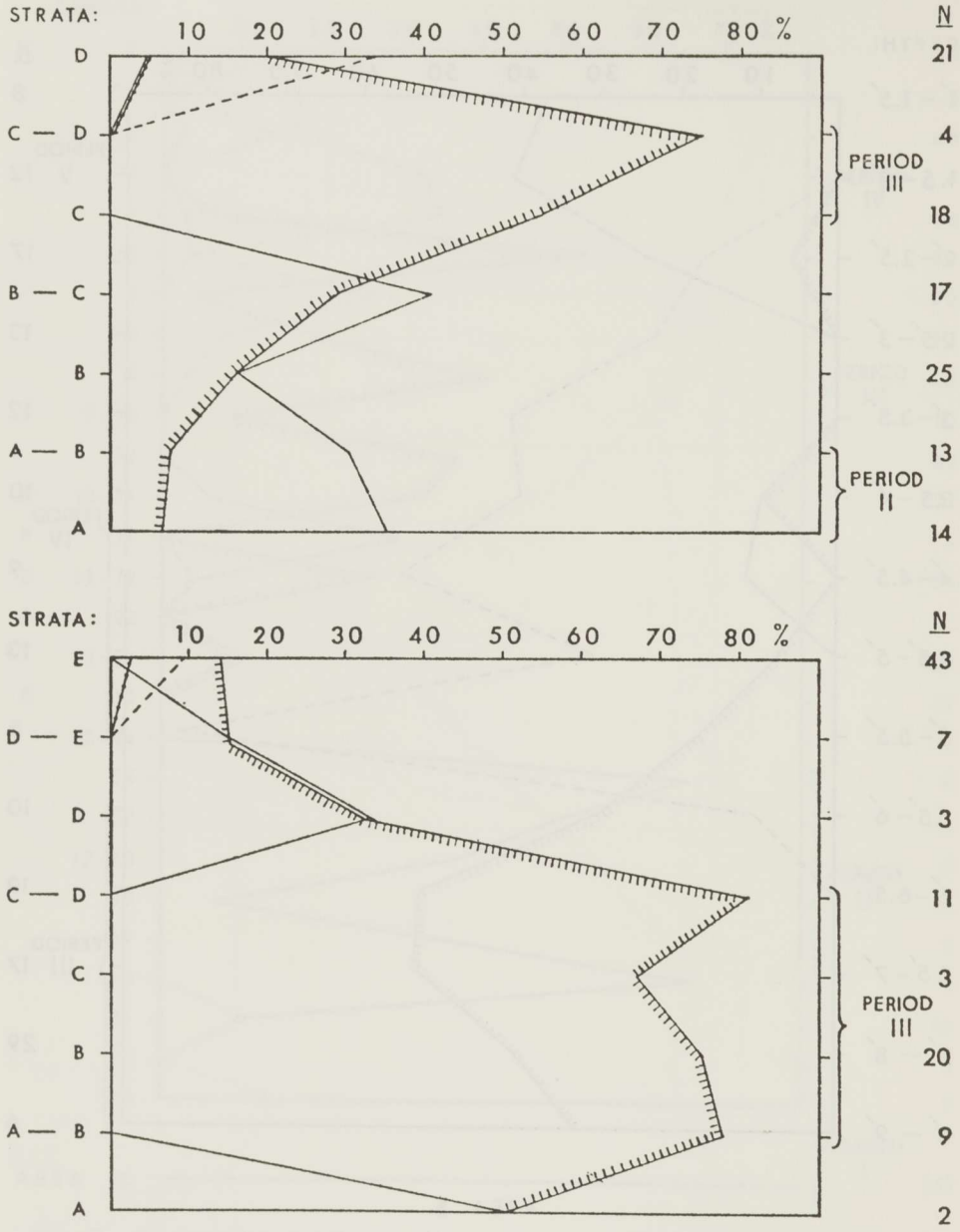


FIG. 9. Stratigraphic distribution of period markers, the Wunderlich Site. Top, Midden A; bottom, Midden B.

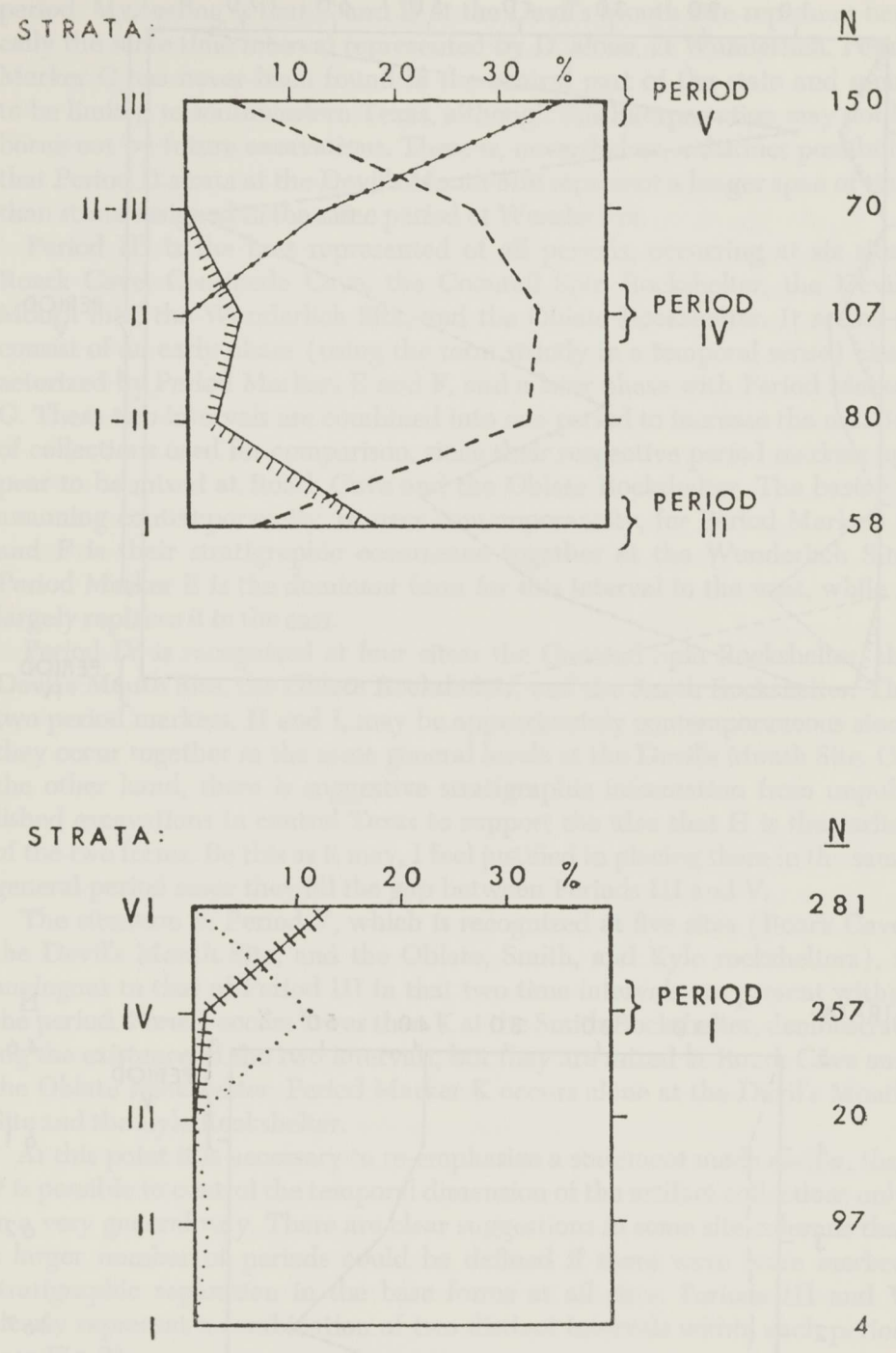


FIG. 10. Stratigraphic distribution of period markers. Top, the Oblate Rockshelter; bottom, the Levi Rockshelter.

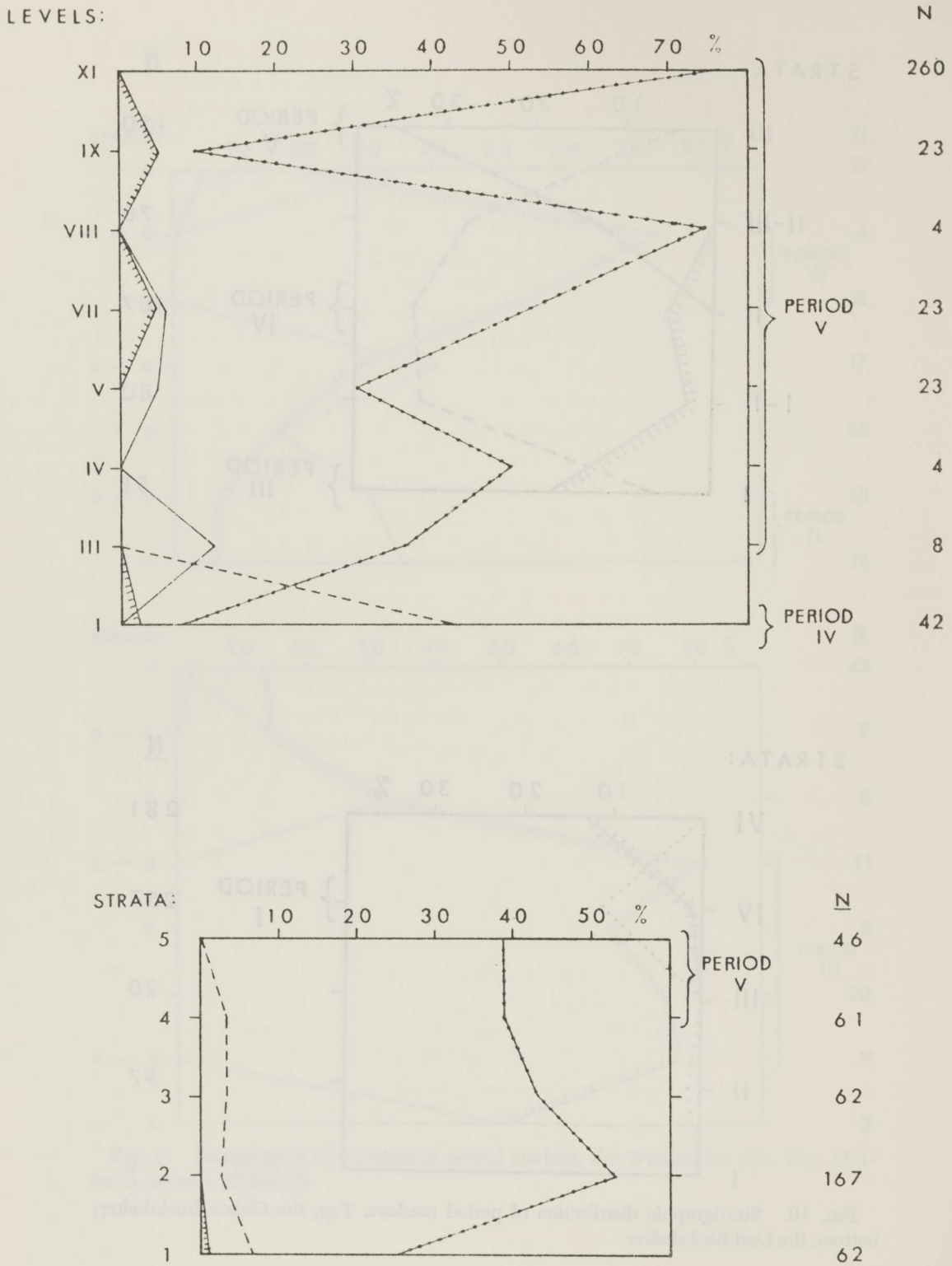


FIG. 11. Stratigraphic distribution of period markers. Top, the Smith Rockshelter; bottom, the Kyle Rockshelter.

period. My feeling is that C and D at the Devil's Mouth Site represent basically the same time interval represented by D, alone, at Wunderlich. Period Marker C has never been found in the central part of the state and seems to be limited to southwestern Texas, although this interpretation may not be borne out by future excavations. There is, nevertheless, a distinct possibility that Period II strata at the Devil's Mouth Site represent a longer span of time than strata assigned to the same period at Wunderlich.

Period III is the best represented of all periods, occurring at six sites: Roark Cave, Centipede Cave, the Coontail Spin Rockshelter, the Devil's Mouth Site, the Wunderlich Site, and the Oblate Rockshelter. It seems to consist of an early phase (using the term strictly in a temporal sense) characterized by Period Markers E and F, and a later phase with Period Marker G. These two intervals are combined into one period to increase the number of collections used for comparison, since their respective period markers appear to be mixed at Roark Cave and the Oblate Rockshelter. The basis for assuming contemporaneity, or near contemporaneity, for Period Markers E and F is their stratigraphic occurrence together at the Wunderlich Site. Period Marker E is the dominant form for this interval in the west, while F largely replaces it in the east.

Period IV is recognized at four sites: the Coontail Spin Rockshelter, the Devil's Mouth Site, the Oblate Rockshelter, and the Smith Rockshelter. The two period markers, H and I, may be approximately contemporaneous since they occur together in the same general levels at the Devil's Mouth Site. On the other hand, there is suggestive stratigraphic information from unpublished excavations in central Texas to support the idea that H is the earlier of the two forms. Be this as it may, I feel justified in placing them in the same general period since they fill the gap between Periods III and V.

The situation in Period V, which is recognized at five sites (Roark Cave, the Devil's Mouth Site, and the Oblate, Smith, and Kyle rockshelters), is analogous to that of Period III in that two time intervals are present within the period. Form J occurs lower than K at the Smith Rockshelter, demonstrating the existence of the two intervals, but they are mixed at Roark Cave and the Oblate Rockshelter. Period Marker K occurs alone at the Devil's Mouth Site and the Kyle Rockshelter.

At this point it is necessary to re-emphasize a statement made earlier, that it is possible to control the temporal dimension of the artifact collections only in a very general way. There are clear suggestions in some site columns that a larger number of periods could be defined if there were more marked stratigraphic separation in the base forms at all sites. Periods III and V clearly represent a combination of two distinct intervals within each period (see Fig. 3).

Lamentably, it is not feasible to make further period divisions. If this were

done at sites with a more perfect stratigraphic segregation of period markers, their finely periodized strata could not be compared to sites lacking these brief temporal distinctions. Thus, the adopted procedure of lumping intervals in certain instances makes it possible, for example, to compare the deposits assigned to Period III at Roark Cave and the Oblate Rockshelter (where Period Markers E and G are intermixed in the same strata) with the Devil's Mouth Site (where E and G have separate distributions). This lumping is justified since it keeps the total number of site collection from being reduced to an insignificant number, and since it increases the size of the specimen sample at certain sites with relatively few artifacts.

An unfortunate side effect of lumping is the inclusion of strata representing unequal segments of time in the same period. For example, it can be seen in Figure 3 that the Period III deposits at Centipede Cave, the Coontail Spin Rockshelter, and the Wunderlich Site represent only the early part of the Period III deposits of Roark Cave, the Devil's Mouth Site, and the Oblate Rockshelter. The inclusion, in cases like this, of strata which are not completely coeval into one period should have little effect on the general study of the temporal continuity of artifact forms in individual sites, but could distort an areal comparison of sites at a given period. Observed dissimilarities between such sites could simply reflect their lack of contemporaneity and mirror temporal changes in artifact forms rather than spatial variation. This possible effect of the periodization procedure must be considered in evaluating the results of the artifact collection analysis.

Chronometric Dating

The succession of periods which has been established for central and southwestern Texas is, at this point, nothing more than a free-floating, "relative" sequence. Strata from different sites have been placed in approximately comparable periods, but no attempt has been made up to now to reckon calendrical time. An attempt will be made to transform the sequence from one that is relative to one that is *chronometric* (the term suggested by Oakley 1964). Chronometric dating means, in this instance, the determination of age in terms of the Gregorian calendar, whether the dates be approximate or exact. The method available in central and southwestern Texas for estimating the chronometric ages of the five periods is the radiocarbon dating technique.

Appendix I lists the results of 59 radiocarbon assays which are deemed appropriate for our periods. Unfortunately, the dates are far from consistent for any one period, or even in many cases for the single site columns from which they come. In spite of their inconsistency, a general idea of the calendrical date of each period can be estimated from the radiocarbon runs.

Twenty-six of the 59 runs were made on material from the nine sites reported here, and there are 33 additional radiocarbon age determinations which can also be used. They are from nine sites in Texas and one in Nuevo León which have not yet been reported in full, and which cannot be used in the present study of artifact forms. Nevertheless, these 33 dates can be applied to the five periods, since they occur with the period markers defined here.

The 33 additional radiocarbon dates were obtained from Fate Bell Rockshelter, Eagle Cave, and Bonfire Rockshelter (all located in Amistad Reservoir, Val Verde County); the Kincaid Site (Uvalde County), the Pohl and Crumley sites (Canyon Reservoir, Comal County), the Penny Winkle Site (Bell County), the Barton Springs Road and Punkinseed sites (Travis County), and Cueva de la Zona (Nuevo León, Mexico).

As stated above, the ranges for the dates of each period overlap enormously.

Period V, A.D. 50–1710 (17 dates)
Period IV, 350 B.C.–A.D. 1245 (8 dates)
Period III, 4580 B.C.–A.D. 110 (14 dates)
Period II, 6810–1315 B.C. (13 dates)
Period I, 8350–4800 B.C. (7 dates)

Evidently, either these ranges are not correct because of their inordinate overlap, or else the period markers which they date are not temporally equivalent. The interpretation preferred here is that the radiocarbon assays are in error. Instances have already been cited of their inconsistency in individual site columns, and the extreme ranges for a period, which are produced by a very small number of assays in each case (see Appendix I), are probably insignificant. The cluster of central dates for each period, however, should be more reliable. Thus the chronometric dates for the periods can be approximated by determining the "central tendencies" of the total runs for each period. If the extremes of the ranges for a period are eliminated, a good chronometric estimate for each can be acquired, although exact period limits or boundaries cannot be specified.

One way of expressing central tendency in a series is to isolate the central, or median, age calculation for each period. The median is the midpoint of an array of dates listed in relative temporal sequence. For periods with an even number of dates, an approximation of the median can be reckoned by averaging the two central dates. The median or central dates for the five periods are as follows:

Period V, A.D. 1365 (Tx–24, Appendix I)
Period IV, A.D. 565 (average of Tx–151 and Tx–81)

Period III, 845 B.C. (average of Tx–47 and Tx–106)
Period II, 4110 B.C. (TxA–544)
Period I, 7350 B.C. (0–1129)

These figures should provide actual dates which fall within each of the five periods. This reveals nothing, however, about the possible range of each since it is impossible to tell where within the periods these values fall.

Another way of measuring central tendency is to select from a series a percentage of dates which cluster equally on both sides of the median sample, and use these to establish broader period limits. This procedure has the benefit of eliminating the extremes from a series of dates, at the same time providing a better idea of range than the single central date. The ranges listed below express the central 50 per cent, approximately, of the runs for each period.

Period V, A.D. 1030–1561
Period IV, A.D. 260–770
Period III, 1460–520 B.C.
Period II, 6730–2630 B.C.
Period I, 8050–5950 B.C.

This method of calculating central tendency gives a range of dates for each period, which is more useful than the single central run. Although there is one case of period overlap (Periods I and II), the expressed limits can be considered as relatively reliable minimum ranges for the five periods. Only more radiocarbon dates can set the period limits in an exact way. There is still a gap of 1,170 years between Periods II and III, 780 years between III and IV, and 260 years between Periods IV and V. A beginning has been made, however, to convert the relative sequence for central and southwestern Texas into a chronometrically dated series of periods.

Artifact Description: The Definition of Lithomorphic Classes

Now that the temporal dimension of the artifact collections has been controlled to a degree, the study of culture-historical integration can progress to a consideration of another necessary dimension: that of form. A comparison of artifact collections demands as a prerequisite the reduction of masses of individual artifact data into formal categories (types, classes, etc.). When these categories are recognized in several collections, they function as indicators of similarity between the collections. By studying shared artifact categories, qualitatively and quantitatively, it can be shown to what extent the artifact collections are similar.

Before considering the subject of typology in detail, it should be explained that only stone artifacts will be considered because of the problems raised by the differential preservation of organic artifacts. The protected sites of southwestern Texas (*e.g.*, Roark Cave and the Coontail Spin Rockshelter) produced abundant vegetal and bone artifacts from certain of their deposits, but open sites which have been long exposed to the weather (the Devil's Mouth Site and the Wunderlich Site) yielded very few organic tools, and those were in poor condition. To be able to make fair comparisons of the artifact inventories from both kinds of sites, only imperishable, lithic tools will be treated.

It is possible to construct several kinds of artifact typologies. In certain cases it is possible to ascertain the function of prehistoric artifacts, and classes such as *axes, projectile points,* and *knives* are recognizable. Artifact forms obtained in prehistoric contexts are compared with the tools used by historic aboriginal people living in the same area, and similarities of form in these cases are usually taken as similarities of function. A broader kind of inference of function can be attempted by establishing "inherent" functions for specific artifact features, where long sharpened edges indicate cutting, pointed ends indicate piercing, and so on. These inferences can be useful, but only in a very general sense. Objections to this method are obvious, since a particular tool form may often serve several purposes; hence to label it with an exclusive function appellation such as *scraper, knife,* or *drill* can be too restricting, and in that sense misleading. In addition, the form of tool may be used for one purpose in one cultural milieu, and for quite a distinct function in a different cultural context. The whole problem of recognizing function from shape is a complex one.

European prehistorians such as S. A. Semenov (1964) have recently applied the principles of microscopy to the recognition of function. Certain lithic artifacts from Middle and Upper Paleolithic sites of western Europe and the U. S. S. R. have been assigned to functional categories from a study of their "wear traces." Under a microscope it is sometimes possible to recognize striations and other use marks, and from their disposition and orientation determine whether a stone tool was used for scraping, cutting, etc.

A second basic way to classify artifacts is to define classes which are merely descriptive, and which reflect morphology, size, or weight, or a combination of these dimensions. Inferences are not made concerning the purpose for which the artifacts were designed; the ideal procedure is to utilize both the functional and descriptive approaches whenever possible.

The writers who reported the nine sites discussed here all have applied functional labels to their tool classes, although strictly formal designations have also been utilized. For several reasons it is impossible to use the functional approach in the present classification. For one thing, the functional labels have been used in conflicting ways by the archaeologists who wrote the reports. There is no over-all uniformity or consistency. To cite a single example, small triangular lithic artifacts from the Oblate Rockshelter were classed by C. D. Tunnell (1962: Fig. 38, A, B) as knives, whereas other workers in the same region commonly called them projectile points. Unfortunately, it is impossible to reconcile the different usages since no adequate criteria have been established locally for the accurate determination of function. Each worker has followed his own feelings without explicitly stating the bases for his functional typology.

This study will not make use of functional classes or types. The functional terms already in use in the literature will be disregarded, and I will suggest none to replace them. At the present stage of our knowledge of southwestern and central Texas archeology it is patently impossible to demonstrate the exact function of even half the lithic artifacts of the area, although the organic artifacts can be classified somewhat more readily. A detailed functional study of the tools used by local historic people is lacking. Regrettably, the possibility of conducting such an analysis now is practically nil, since local peoples were exterminated or absorbed before their original life ways were accurately recorded. The few extant Spanish colonial documents, many of which are still unstudied, may be able to shed some light on the problem but their use to date has not produced exciting results. If and when reconstructions as to artifact function are made, the conclusions will have to be formed in large part by making comparisons with people from other areas. And this will restrict the precision of the inferences.

Also, microscopic examinations of the type performed by Semenov will some day have to be carried out. Such studies may alter considerably the

current use of functional labels. Many tools now described in Texas as *projectile points, knives*, etc., may have to be reclassified. A good example of mistake in identification is the case, in the Old World, of the so-called shouldered points of the Upper Paleolithic recovered from Kostenki I, Willendorf, Grimaldi, Berdyga, etc. Semenov's (1964: 93, 94) microscopic study of the "projectile points" from Kostenki I revealed evidence of polishing near the tips of the points and on the forward part of the blade. Obviously this tool form served as a knife, perhaps for ripping open carcasses or dismembering game. With this case in mind, there is every reason to beware the current, unsupported employment of function labels in Texas archeology.

With the rejection of the definition of functional artifact classes, the use of simple descriptive classes remains as an alternative. The selection of the criteria for classification is not an easy matter, and wholly different approaches appear in the archeological literature. A member of the Santa Fe conference on typology described the current situation aptly in stating that "typology, in America at least, is a frightening mess of ambiguous terms, groups of artifacts formed by no apparent principles, and impossible to understand" (anonymous statement in Krieger 1964: 491).

Among the attributes usually used to establish descriptive taxa are details of shape and proportions, weight, materials used in manufacture, and techniques of manufacture. The recent work of the archeology staff of the University of Utah has demonstrated the utility of multiple trait analysis for recording attributes and their clusters (Anonymous 1964). This demonstration of descriptive types through statistical techniques would obviously be the ideal procedure to follow here, since it would hopefully produce cohesive clusterings of associated attributes (traits) which could be crystallized into named types. The practice will not be allowed for several reasons. One of the most important is that accurate statistical studies of the co-variance of attributes for the thousands of artifacts from the nine Texas sites, even using data processing equipment, would demand enormous quantities of time and energy. J. D. Jennings (1963) experienced this difficulty at the University of Utah where an attribute analysis of 2,600 lithic specimens was tried. Only a few hundred artifacts were successfully analyzed because of the time factor involved in coding.

A more serious stumbling block to trait analysis with the Texas artifacts is the fact that the published artifact descriptions are far too general to allow this technique to be used, as not all the possible artifact attributes are described in the same detail. The descriptive lumping of artifacts which show attribute variability is the main limitation of the published reports. And it is now veritably impossible to reclassify the artifacts to record omitted variables. The artifacts themselves, in many cases, are not available for restudy.

Those from Roark Cave and some from the Kyle Rockshelter are in the possession of amateur archeologists and are widely scattered.

An alternative, admittedly compromise, method of classification will have to be used here. Descriptive artifact classes will be established by using only the accessible descriptive data, those that appear in the published accounts or manuscripts. The classification will not be as complete as desired, since it cannot take into account all the variables that occur in the artifacts.

One basic class of variables which would be useful, but which must be eliminated, is the one having to do with techniques of manufacture. Some of the published reports discuss these attributes, but a majority omit them entirely. Actually, this omission is not particularly serious since there are obvious errors in many of the publications which do try to treat this question. Serious mistakes can be made when trying to distinguish in lithic artifacts between hammerstone percussion chipping, billet flaking, pressure chipping, bipolar percussion, and other methods of flintknapping without advice from persons familiar with these techniques or without actual experiments on stone. And the authorities on the subject are by no means united in their interpretations.

Another variable which could profitably be used in classification, but which cannot here, is artifact weight. Only the Oblate Rockshelter report includes weight data (Tunnell 1962), but even in this case weight information is provided for a restricted number of artifact classes.

The attributes which can be dealt with are those which fall under the headings of general morphology and gross size. Information of this kind is available for all nine site collections. Since only these variables can be controlled, the artifacts grouped in any of the following descriptive classes are to be considered similar, then, only in that they exhibit the specified formal and dimensional features. They may differ as to weight, techniques of manufacture, or in other variables.

Since the use of the term *type* connotes a fuller treatment of attributes than is done here, its use will be avoided. For this reason, and also because they have not been applied in a consistent way in the site reports, none of the type names which appear in the local archeological literature will be used. It is proposed that the following descriptive units should be called *lithomorphic classes, i.e.,* categories of stone artifacts defined primarily by their form. Each class, or form, is given a numerical designation, and the published labels for the artifacts included in it are listed in Appendix II, as they appear in the site reports.

A total of 50 lithomorphic classes is recognized. The artifacts are unmistakably modified by human agency, inferentially for use as tools. Manufacturing debris (flakes and cores), raw materials destined for tool production, and objects which appear to be designed for esthetic or symbolic ends (*e.g.,*

painted and scored pebbles) are omitted although some of them were classified as tools in the site reports. Largely, however, I have had no recourse but to accept the judgments of the authors of the site reports as to whether certain specimens are tools or not.

When the general morphology of the artifacts is examined, two very distinct patterns emerge. First, there is a large group whose members have been modified by chipping or grinding practically the whole surface area. It seems that the entire artifact was worked in accord with a clear stereotype or ideal pattern in the mind of the maker.

The second group of specimens shows only a partial modification of the total artifact. Examples are flakes chipped along one or more edges, cobbles and slabs of stone with grinding facets, and the like. There is no reworking of the total surface of the specimen in terms of a general pattern, but only a modification of a specific edge or surface. Specimens of this second group show a considerable variety of form except in the modified area.

The first category of specimens shall be referred to as *shaped* artifacts, and the second group shall be called *unshaped* artifacts. Both types have in fact been "shaped" but this selection of labels points out the distinction drawn between them. *Shaped* artifacts are worked in their entirety to a preconceived pattern. The *unshaped* specimens are only partially modified, although this modification is also patterned. The total form of the *unshaped* tools can be specified only within very broad limits and is of secondary importance for classification.

The morphology of *shaped* artifacts will be described in terms of two dimensions: outline shape and cross section shape. Adjectives with a geometric or organic model (triangular, oval, laurel-leaf shaped, and so forth) are used, or modifications of the basic terms (subtriangular, ovaloid, etc.). The lithomorphic classes labeled with these descriptive terms are, in a sense, ideal classificatory categories. The artifacts which are included in a class are closely similar to the basic form indicated, yet not one of the artifacts described as "triangular" has the outline of a perfect triangle. The ideal nature of this kind of classification permeates the whole field of artifact typology.

The cross section descriptions of *shaped* artifacts refer exclusively to the latitudinal cross section of the artifact extending across the shorter axis. There is little information in the published reports on longitudinal cross section. In the case of artifacts which have radial as opposed to bilateral symmetry, this distinction does not apply.

Outline drawings of the lithomorphic classes of the *shaped* category appear in Figs. 12 and 13.

The description of the *unshaped* artifacts is perforce different from that used with *shaped* specimens. Geometric terms do not lend themselves to a description of the irregular form of the total artifacts. In place of this kind

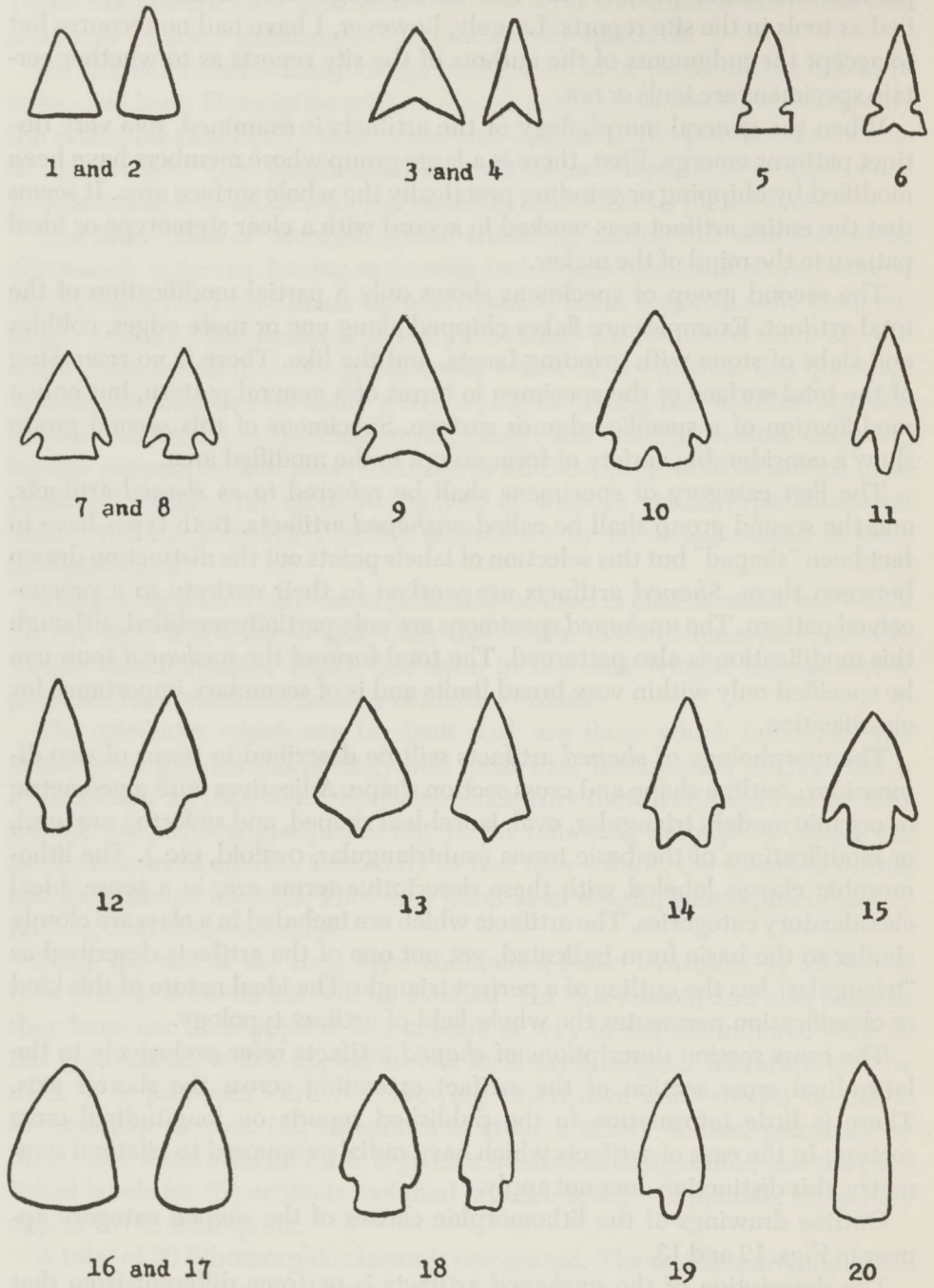


FIG. 12. Idealized outline sketches of lithomorphic classes 1–20. All classes have biconvex (lenticular) cross sections. Not to scale.

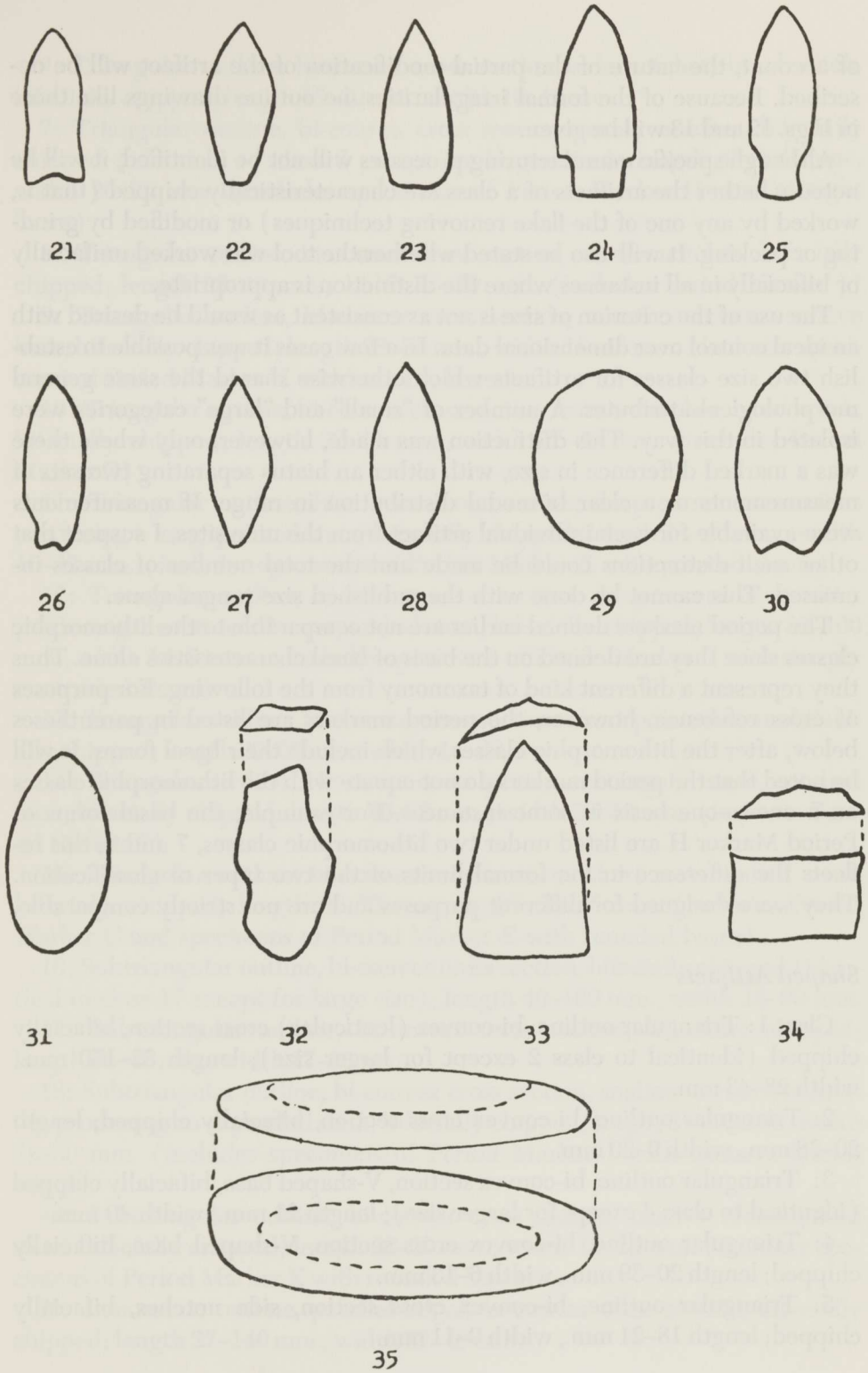


FIG. 13. Idealized outline sketches of lithomorphic classes 21–35. All classes lacking cross section drawings have bi-convex (lenticular) cross sections. Not to scale.

of account, the nature of the partial modification of the artifact will be described. Because of the formal irregularities, no outline drawings like those in Figs. 12 and 13 will be given.

Although specific manufacturing processes will not be identified, it will be noted whether the artifacts of a class are characteristically chipped (that is, worked by any one of the flake removing techniques) or modified by grinding or pecking. It will also be stated whether the tool was worked unifacially or bifacially in all instances where the distinction is appropriate.

The use of the criterion of size is not as consistent as would be desired with an ideal control over dimensional data. In a few cases it was possible to establish two size classes for artifacts which otherwise shared the same general morphological attributes. A number of "small" and "large" categories were isolated in this way. This distinction was made, however, only where there was a marked difference in size, with either an hiatus separating two sets of measurements or a clear bi-modal distribution in range. If measurements were available for each individual artifact from the nine sites, I suspect that other such distinctions could be made and the total number of classes increased. This cannot be done with the published size ranges alone.

The period markers defined earlier are not comparable to the lithomorphic classes since they are defined on the basis of basal characteristics alone. Thus they represent a different kind of taxonomy from the following. For purposes of cross reference, however, the period markers are listed in parentheses below, after the lithomorphic classes which include their basal forms. It will be noted that the period markers do not equate with the lithomorphic classes on a one-to-one basis in some instances. For example, the basal forms of Period Marker H are listed under two lithomorphic classes, 7 and 9; this reflects the difference in the formal limits of the two types of classification. They were designed for different purposes and are not strictly comparable.

Shaped Artifacts

Class 1: Triangular outline, bi-convex (lenticular) cross section, bifacially chipped (identical to class 2 except for larger size); length 32–150 mm., width 28–43 mm.

2: Triangular outline, bi-convex cross section, bifacially chipped; length 20–28 mm., width 9–20 mm.

3: Triangular outline, bi-convex section, V-shaped base, bifacially chipped (identical to class 4 except for larger size); length 21 mm., width 40 mm.

4: Triangular outline, bi-convex cross section, V-shaped base, bifacially chipped; length 20–39 mm., width 6–13 mm.

5: Triangular outline, bi-convex cross section, side notches, bifacially chipped; length 18–21 mm., width 9–11 mm.

6: Triangular outline, bi-convex cross section, side notches, basal notch, bifacially chipped; length 15–20 mm., width 10–15 mm.

7: Triangular outline, bi-convex cross section, corner notches, bifacially chipped (identical to class 8 except for larger size); length 40–120 mm., width 20–70 mm. (includes specimens of Period Marker H with straight bases)

8: Triangular outline, bi-convex cross section, corner notches, bifacially chipped; length 25–43 mm., width 15–20 mm. (includes Period Marker J)

9: Triangular outline, bi-convex cross section, corner notches, concave base, bifacially chipped; length 22–80 mm., width 18–45 mm. (includes specimens of Period Marker H with concave bases)

10: Triangular outline, bi-convex cross section, corner notches, basal notch, bifacially chipped; length 38–73 mm., width 27–40 mm. (includes Period Marker G)

11: Triangular outline, bi-convex cross section, deep corner concavities producing a long, pointed stem, bifacially chipped; length 14–40 mm., width 10–22 mm. (includes specimens of Period Marker K with pointed stems)

12: Triangular outline, bi-convex cross section, deep corner concavities producing a contracted or expanded stem, bifacially chipped; length 30–100 mm., width 14–54 mm. (includes specimens of Period Marker E with sharply contracted stems)

13: Triangular outline, bi-convex cross section, short pointed stem, bifacially chipped; length 20–30 mm., width 14–22 mm.

14: Triangular outline, bi-convex cross section, rectangular stem, notched base, bifacially chipped; length 36–78 mm., width 20–52 mm. (includes Period Marker F)

15: Triangular outline, bi-convex cross section, short rectanguloid stem, bifacially chipped; length 30–75 mm., width 20–45 mm. (includes Period Marker C and specimens of Period Marker E with rounded bases)

16: Subtriangular outline, bi-convex cross section, bifacially chipped (identical to class 17 except for large size); length 40–160 mm., width 18–90 mm.

17: Subtriangular outline, bi-convex cross section, bifacially chipped; length 30–40 mm., width 17–23 mm.

18: Subtriangular outline, bi-convex cross section, shallow corner concavities producing an expanded stem, bifacially chipped; length 21–55 mm., width 15–30 mm. (includes specimens of Period Marker I with concave lateral edges)

19: Subtriangular outline, bi-convex cross section, narrow rectanguloid stem, bifacially chipped; length 28–39 mm., width 18–22 mm. (includes specimens of Period Marker K with rounded bases)

20: Lanceolate outline, parallel edges, bi-convex cross section, bifacially chipped; length 27–140 mm., width 27–40 mm.

21: Lanceolate outline, bi-convex cross section, concave base, bifacially chipped: length 30–85 mm., width 16–32 mm. (includes Period Marker B)

22: Lanceolate outline, bi-convex cross section, contracted base, bifacially chipped; length 33–59 mm., width 18–40 mm.

23: Lanceolate outline, convex edges, bi-convex cross section, bifacially chipped; length 36–81 mm., width 20–61 mm.

24: Lanceolate outline, bi-convex cross section, long rectanguloid stem, bifacially chipped; length 43–67 mm., width 18–45 mm. (includes specimens of Period Markers D and I with straight lateral edges)

25: Lanceolate outline, bi-convex cross section, shallow lateral concavities producing straight or expanded stems, bifacially chipped; length 30–91 mm., width 11–30 mm. (includes specimens of Period Marker D with lateral concavities)

26 (residual category): Lanceolate outline, bi-convex cross section, stems of irregular shapes, bifacially chipped; length 35–67 mm., width 20–31 mm.

27: Laurel-leaf outline, bi-convex cross section, pointed base and tip, bifacially chipped; length 43–105 mm., width 17–46 mm. (includes Period Marker A)

28: Laurel-leaf outline, bi-convex cross section, convex base and pointed tip, bifacially chipped; length 38–130 mm., width 19–55 mm.

29: Circular to oval outline, bi-convex cross section, bifacially chipped; diameter 34–90 mm.

30. Ovaloid outline, bi-convex cross section, concave base, bifacially chipped; length 94–118 mm., width 51–59 mm.

31: Long ovaloid outline, bi-convex cross section, bifacially chipped; length 30–131 mm., width 21–71 mm.

32: Irregular outline, trapezoidal cross section, bifacially chipped, edges beveled by chipping on opposing faces; length 95 mm., width 32 mm.

33: Trianguar outline, plano-convex cross section, unifacially chipped, all edges thin; length 46–98 mm., width 44–60 mm.

34: Rectangular outline (gunflints?), trapezoidal cross section, unifacially flaked; length 20–27 mm., width 16–23 mm.

35: Rectanguloid outline, concavo-convex cross section, bifacially pecked and ground with depression worked into convex surface; length 155 mm., width 48 mm.

Unshaped Artifacts

Class 36: Flakes with irregular or rectanguloid outline, plano-convex cross section, bifacially chipped, opposite or adjoining edges chipped on opposing faces; length 38–80 mm., width 26–55 mm.

37: Crude bifacial tools made from large flakes, irregular outlines, bi-

convex or asymmetrical cross section, bifacially chipped; diameter 59–130 mm.

38: Flakes with subtriangular outline, plano-convex or concavo-convex cross section, thick chipped bit opposite triangular apex, sides frequently worked, surface unifacially chipped; length 27–51 mm., width 15–55 mm.

39: Flakes with subtriangular outline, bi-convex cross section, concave chipped edge (bit) opposite triangular apex, edges worked, unifacially chipped; length 61–71 mm., width 31–60 mm.

40: Large flakes with ovaloid outline, plano-convex cross section, edges chipped around majority of circumference, unifacially worked; diameter 25–80 mm.

41: Long flakes with irregular outline, plano-convex cross section, one or more long edges chipped, unifacially worked; diameter 26–138 mm.

42: Flakes with irregular outline, plano-convex cross section, chipped concavity on one edge, unifacially worked; diameter 30–107 mm., width across concavity 6–23 mm., depth of concavity 3–9 mm.

43: Flakes with irregular outline, plano-convex cross section, one edge serrated with shallow concavities, unifacially chipped; diameter 45–99 mm.

44: Pebbles and cobbles with ovaloid outline, oval cross section, bifacially or unifacially chipped on one edge; diameter 45–152 mm.

45: Pebbles or cobbles with subtriangular (amigdaloidal) outline, bi-convex cross section, bifacially chipped over a part of the artifact, on two edges which come together to form a distinct point; length 78–104 mm., width 50–81 mm.

46: Flakes with irregular outline, plano-convex cross section, unifacially chipped on one edge where two adjacent concavities form a protruding tip (bit) between; diameter 35–59 mm., length of bit 2–9 mm.

47: Flakes with irregular outline, irregular cross section, long projection (bit) bifacially chipped with diamond-shaped cross section; length of projection 14–40 mm.

48: Flakes or broken artifacts with varied outlines, irregular cross section, side-worked long flake scar(s) on one or two edges at right angles to the surface of the artifact producing a sharp projection (burin bit); diameter 43–55 mm.

49: Stone slab with ovaloid outline, plano-concave or bi-concave cross section produced by grinding facets on one or both surfaces; diameter 290–330 mm.

50: Cobbles with ovaloid outline, plano-convex or bi-convex cross section produced by grinding facets on one or both surfaces; diameter 90–150 mm.

Selection of a Technique for Statistical Comparison

Among the earliest statistics used in anthropology is the association coefficient, employed as a measure of degree of association between groups of culture traits. The antecedents of this approach can be traced to the nineteenth century studies of Edward B. Tylor (1889) and Sebald R. Steinmetz (1894). In practice, it was assumed that all correlations were the expression of historical-geographical connections and patterns. Notable examples are the studies of Jan Czekanowski (1911, 1935), Stanislaw Klimek (1935), and Wilhelm Milke (1935) who were primarily interested in doing distributional comparisons as an aid in the study of diffusion. These and many other studies conducted up through the early 1940's used, by and large, one or more of the Q coefficient formulas developed by Pearson and Yule, or closely related statistics such as *phi*. The application of the association coefficient to the problem of constructing culture patterns, whether archeologically or ethnographically, has several serious disadvantages. The association coefficients can take account only of the presence or absence of a trait, type, or class—not the comparative intensity of its occurrence. This feature severely limits the technique for any general definition or description of archeological patterns where the quantities of each trait need to be treated together.

The best early attempt to apply statistics to the problem of defining and describing archeological units is the historically important analysis which A. L. Kroeber performed in 1940. He set out to evaluate archeological units already reported in Tennessee (the Norris Basin complex) and in Ohio and Kentucky (the Fort Ancient aspect). Kroeber's study is similar to that of early workers in ethnology in that he uses simple association statistics, in his case R and Z coefficients (Kroeber 1940: 33, 34). Kroeber's analysis treats a large number of traits at once, but exclusively on a presence-absence basis. In this study, R and Z coefficients are worked out, site by site, in four-cell calculations; coefficients are compared and similarly high coefficients are considered as indicators of likeness. A tabular technique is used to present and organize the data which is identical to the matrix method of Robinson (1951) employed over a decade later.

In the example of the Norris Basin archeological complex, Kroeber constructed a tabular matrix with the coefficients for all sites plotted both on horizontal and on vertical axes. The higher coefficients were arranged so that they fell along a diagonal, with the lower values clustering in the two remaining corners (Kroeber 1940: Fig. 5). The next step in the analysis was to group

relatively high values together in clearly discernible clusters, *i.e.*, archeological units.

Kroeber's system treats all variations (in indexes) as geographic-cultural differences, and does not allow for change in terms of temporal fluctuation. In this respect, his interpretation is the inverse of that of Robinson, where variations in index values are taken as temporal variations.

These statistical techniques show one feature which would limit severely their application to the task of delimiting and defining archeological units or other patterns. They consider traits or attributes only on a present-absent basis, and do not deal with data quantification in a strict sense.

The common statistical techniques which treat data frequency can be divided into four categories: (1) the Robinson coefficient technique (Robinson 1951; Brainerd 1951; Belous 1953; Dixon 1956; Driver 1956; Driver and Massey 1957; Troike 1957; and Flanders 1960), (2) the three pole graph technique (Meighan 1959; Ascher 1959), (3) the correlation scatterplot technique (Witherspoon 1961), and (4) the cumulative graph technique (Bordes 1952; de Sonneville-Bordes 1960; Jelinek 1960, 1962; Litvak King 1964). The majority of these studies are not directed primarily to the problem of defining basic units or patterns. Most are seriation studies whose purpose is to rank sites or artifact collections in temporal sequences or series. Yet the techniques which several of them employ could be appropriate for recognition of general patterns of uniformity, since they make accurate comparisons of artifact collections. These techniques all attempt to demonstrate resemblances and differences between artifact collections by considering variations in the relative frequencies of artifact types or traits.

The year 1951 saw the joint publication by W. S. Robinson and G. Brainerd of a technique to determine the similarity between artifact collections for purposes of constructing temporal sequences. The basic tenet involved is that collections which are close together in time will show similar frequencies of their respective artifact types. To measure percentage distributions, a coefficient of agreement is determined. This is obtained by calculating the percentages for each artifact type in all collections to be used in the study, and by comparing each collection with all the others in respect to the percentages of each artifact type. Type by type, the smaller percentage (of whichever collection) is subtracted from the larger, and the remainders for all types are added to provide the total difference between the collections. Next, this figure is subtracted from the figure 200 (100 per cent for each site) to obtain an index of similarity between the two collections. The final result is a number of coefficients, one for each of the possible pairs of collections. This is the important part of the study from the standpoint of the possible utility of the Robinson technique for defining archeological patterns of similarity. These indexes, since they are numerical expressions of the degree

of similarity existing between all pairs of collections, could serve as a basis for grouping similar sites into units or other patterns, and for drawing their limits in numerical terms. The fact that the Robinson technique has not yet been applied to this problem in no way reflects on its possible utility.

However, Robinson and Brainerd were not interested in unit or pattern definition, but in seriation. Where it could be assumed that the entire area being analyzed shared the same material culture, it was held that any changes which occurred must have happened at about the same time. Since fluctuations in the indexes of similarity reflect fluctuations in the relative popularity of the artifact types, collections close in time must have similar percentage distributions. When the additional assumption is made that each type has a lenticular distribution pattern—that it originates at a given time, occurs in gradually increasing numbers, and then decreases in frequency until it disappears—then the Robinson technique can be used to create a temporal rank-order for collections as follows. Similarity indexes are plotted in tabular form just as Kroeber (1940: Fig. 5) did with his earlier study. All collections are listed on the vertical and horizontal axes, with the indexes at the intersections. The columns and rows are next shifted until the highest indexes are located along a diagonal, with a continuous decrease of the numbers away from the diagonal in both directions. The final sequence of collections should reflect a correct temporal order.

The use of the Robinson technique has not been as widespread as one might expect for such a method, in part perhaps because of the large amount of time necessary to carry out the computations and matrix ordering. Recent attempts to computerize the procedure (Ascher and Ascher 1963; Kuzara and Dixon, verbal communication, 1965) have significantly reduced the time element involved in the work, so that a greater utilization of the method may be expected in the future. However, several applications have already been made with some degree of success by R. E. Belous (1953), K. A. Dixon (1956), R. C. Troike (1957b) and R. E. Flanders (1960).

The only attempts by non-archeologists to use the Robinson technique are the studies of H. E. Driver (1956) and Driver and W. C. Massey (1957: 425–434) which deal with kinship terms, descent, land tenure, residence, and division of labor in American Indian societies. A possible evolutionary-historical sequence of forms was obtained. With this exception, all the applications have been in the field of archeology.

Brief mention will be made here of a seriation technique published by C. W. Meighan (1959; Ascher 1959). This is the so-called three-pole graph method. It is designed as a shorthand method for collection seriation and considers only a small number of types or traits simultaneously. Relative frequencies are determined for three artifact types (usually the three most abundant), where only these types equal 100 per cent. All collections are

plotted on a three-pole graph. Normally their loci tend to cluster along an axis, their linear arrangement showing the nearness of the collections to each other in respect to the proportions of the three selected artifact types. As in the use of the Robinson technique, differences in proportions (and hence differences in location on the axis) are considered expressions of temporal differences in the collections. This technique could be used for comparing artifact collections in cases where the time variable is held constant, but it is not recommended. First, it deals with only three types or traits simultaneously, not with a complete artifact assemblage; and second, it cannot deal with types which may be absent from one of the collections. As a quick guide for seriation studies, however, the three-pole graph technique has many advantages, not the least of which is its ease of application.

A technique for comparing collections which is very much like Robinson's in some ways is Y. T. Witherspoon's correlation scatterplot (1961). This is a quantitative method based on the Q-technique which has been applied to behavioral psychology by W. Stephenson (1953). When two artifact collections are compared, each trait or type has to be evaluated on the basis of the frequency of its occurrence in each, and assigned to one of the following categories: not present, trace, moderate, frequent, or predominant. A table is prepared with the frequency categories of one of the two collections along one axis, those of the other collection along the other axis. The types are each assigned a value of one, and tallies are made for all types of both collections in the proper frequency cells.

The Stephenson formula, when applied to the tabular figures, produces a correlation coefficient usable as a simple descriptive measure of resemblance. It provides an index of similarity or dissimilarity between the two collections. These indexes, for all possible pairs of collections, could be used like those of Robinson for doing seriation or they could be used to distinguish archeological units or other patterns. The range of coefficients runs from −1.00 to +1.00, −1.00 representing the greatest possible dissimilarity, +1.00 representing the greatest possible similarity. The major disadvantage of the correlation scatterplot is that it treats quantitative data as broad categories (moderate, frequent, etc.) and for this very reason is not so sensitive an indicator of similarity as the Robinson coefficient of agreement.

The cumulative graph technique, which is statistical only in the loosest sense, has only recently been employed in archeology. F. Bordes (1952) and many of his associates (*e.g.*, de Sonneville-Bordes 1960) have used the cumulative graph to compare Old World Paleolithic stations according to the percentages of types in each sample. A. J. Jelinek (1960, 1962) used the cumulative graph as a device for temporal ordering, applying the technique to archeological materials from the Pecos River and adjacent Great Plains area of eastern New Mexico. In the Valley of Mexico, J. Litvak King (1964)

used the cumulative graph to order a series of strata containing pottery styles ranging from the Classic through the Toltec, Aztec, and Modern periods.

The cumulative graph technique is not difficult to use, normally taking much less time to construct than either bar graphs or Robinson matrixes. The graph has types arranged on one axis and percentages on the other. Type percentages are added together to form a single line which advances from zero per cent in the lower left corner to 100 per cent in the upper right corner. The line represents an "increasing" series showing the accumulation of each artifact type on the scale.

Once lines for all the collections are plotted relative to each other on the same graph, the nearness of the lines expresses the formal and quantitative likeness of the collections to each other. This orderly horizontal progression of lines may be considered as a temporal progression, as in the publications of Jelinek and Litvak King. On the other hand, if the temporal dimension is controlled, the cumulative graph can be used for grouping artifact collections into basic units or other general patterns. Collections whose lines occurred close together may be placed in the same descriptive category.

The discussion of one comparative technique which deals only with the presence and absence of types or traits has been delayed until after the discussion of the methods of Robinson and others, of which it is an outgrowth. This is the seriation technique of P. Dempsey and M. Baumhoff (1963). Like most of the foregoing writers, Dempsey and Baumhoff use artifact distributions to establish chronological sequences. Therefore, there are many aspects of their study which are of no interest here since they pertain strictly to problems of seriation. For instance, there is a long discussion on the selection of desirable artifact types and the exclusion of others in achieving the "best" temporal differentiation between collections. In addition, a process is provided whereby certain types can be weighted more heavily than others, so that those which are most sensitive for seriation can be counted most heavily. These refinements apply only to problems of seriation and will not be discussed here. Except for the fact that percentages are not utilized, the steps involved in the Dempsey-Baumhoff technique are much like those followed by Robinson (1951).

The portion of the technique which might be of use to archeologists for defining general patterns of similarity between collections is the contextual study of traits according to a binary system, where traits (or types, or attributes) are scored on a present or absent basis. Matrix of agreement scores analogous to those of Robinson are secured. In the Dempsey-Baumhoff technique, the index of agreement for each pair of artifact collections is a summation of common responses. When a type is present in both collections being compared, a tally is made. Likewise for a type absent from both. When a type is observed in one collection but not in the other, no tally is made. Therefore,

if there were 52 traits or types, the maximum agreement score which can be obtained would be 52, and zero would be the minimum. It would be possible for one to compare sites or collections simply on the basis of these agreement scores, and thus recognize and isolate clusters of similar scores.

Lipe points out (1964) that, because of its dependence on presence and absence counts, the Dempsey-Baumhoff seriation statistic may not be as useful as the Robinson technique in two kinds of situations: in instances where a few artifacts from one period have been mixed with those of another time interval, and in situations where most of the artifact types are defined by variable or metrical, as opposed to discrete, attributes (for a full discussion of the problems, see Lipe 1954: 103–104).

Two additional techniques will be mentioned only in passing: numerical cluster analysis and factor analysis. In 1954, Forrest E. Clements described an approach to defining clusters that accomplishes much the same as the matrix cluster definitions done by the Berkeley culture-element distribution studies. His numerical technique is more precise than matrix or graphical cluster analysis because of its use of high-powered statistics; at the same time, however, matrix cluster analysis is able to show "genetic" relationships between clusters more readily than Clements' technique.

The use of factor analysis in anthropology has been surveyed by Tugby (1965: 7–10) and Milke (1965: 195–196). Factor analysis is based on the notion that there may be some inherent structure which governs the interrelationships and correlations among variables. It can reduce the number of dimensions to a set of factors which account for major co-variation among the variables. This statistical technique can tell us, in a sense, exactly "what is going on" in our clusters if the two techniques are used together.

Selection of the Robinson Technique

The above statistics operate in different ways, and it is necessary to select from among them one which can produce good results with the kinds of data which are available. Two ideal conditions or prerequisites for a statistical comparison and appraisal of the Texas collections can be set. First, the selected statistic should handle data frequency as well as qualitative information, and second, it should express its results in as specific a form as possible.

There are two advantages to doing quantitative studies of artifact classes as opposed to a mere presence and absence analysis of items. For one thing, the frequency of an artifact class is usually a reflection of its relative importance and popularity. Spatial and temporal differences in class frequency should therefore be taken into account in defining general archeological patterns. Also, the treatment of classes according to quantity makes it pos-

sible to compensate for two possible distortions in the data. Simply because of their size, large collections are apt to have greater numbers of rare artifact classes than small samples. With wide differences in the sizes of the Texas collections, it would be unfair to carry out a general comparison on a presence or absence basis alone. Furthermore, it is likely that a few of the artifacts in any one of the 20 collections are specimens from other time periods which have been dislocated from their original loci (see Lipe 1964). A quantitative description of each collection will tend to minimize their effect on the resultant statement of similarity since the intruded artifacts usually occur in small numbers. A qualitative description would give all classes equal impact, whether they are abundant or uncommon.

The importance of the second prerequisite, the specific statement of results, is self-evident since it permits a precise manipulation of data.

The statistical studies which were undertaken by Czekanowski, Klimek, Milke, Kroeber, and Dempsey and Baumhoff fail to measure up to the first prerequisite; they deal only with counted items or types, not with their relative abundance.

The first condition, quantitative treatment of each item or artifact category, is met by the Robinson-type studies, the three-pole graph technique, the correlation scatterplot, and the cumulative graph technique. The three-pole graph technique can be eliminated since it treats only three groups of data, not a large assortment of types or artifact classes. Now the problem arises of selecting one technique from those that remain. The application of the second prerequisite makes it possible to exclude the correlation scatterplot since it lumps artifact percentages into general categories such as "trace," and is therefore not so sensitive as the Robinson technique which considers precise percentage calculations. The cumulative graph can also be ruled out, although with more hesitation, because of its failure to compete with the Robinson technique with regard to the second prerequisite. The graph does not state resemblances between collections numerically, only in terms of horizontal distance. This is not necessarily a less exact measure of relationships. Its results are just harder to appreciate and more difficult to manipulate since they depend on visual inspection.

Discussion of Clements' numerical cluster analysis and factor analysis has been delayed deliberately. Actually, my feeling is that both techniques might yield fruitful results if applied to the Texas data. However, Clements' cluster analysis is not used because of the large amount of time demanded for the necessary calculations. If the process can be programmed for computer, then experimentation with numerical cluster analysis would be in order with the data used in this paper.

Factor analysis presents a more difficult problem. In theory, factor analysis could be an important adjunct to any cluster analysis as it would determine

what combination of types or traits is "causing" a cluster. Yet the available computer programs may need to be modified before being used with the Texas archeological data. Milke (1965: 196) explains his own misgivings about the use of factor analysis programs in anthropology by cautioning against the danger of accepting unwittingly the underlying statistical models of current programs. Experimentation with factor analysis needs to proceed for a while before I, at least, will feel free to use the technique.

By one means or another all the comparative procedures have been eliminated except the Robinson technique. It meets both prerequisites, and will be used to determine the degree of similarity of the 20 artifact collections. The numerical statements of similarity, one for each possible pair of collections, will function as a guide for recognizing spatial-temporal patterns of uniformity.

The Statistical Analysis

The 20 periodized collections from central and southwestern Texas were compared in the standard manner prescribed by Robinson (1951), as outlined previously. The percentage of each lithomorphic class was worked out for all collections, and these relative frequencies were compared for all possible pairs of collections to produce indexes of agreement. The indexes number 190 (excluding the indexes of identity), and are presented in Fig. 14. The total range of the indexes is 111, extending from 12 at the lowest end of the scale to 123 at the highest. The mean value of the 190 indexes is 55.9, and the mean deviation is 20.4

Before discussing the matrix ordering of indexes and their patterning, it will be beneficial to consider the general nature and meaning of the indexes. First, they are very complex indexes in spite of the simplicity of their calculation, since many classes of artifacts enter into their computation. The total number of lithomorphic classes per collection varies from 11 to 27, with an average of 18. The resultant indexes can only portray general, abstract statements of similarity, which contrast with comparisons of archeological components where individual types or classes are specified. The comparison which will be carried out here, contrariwise, will be done on a more abstract level, since similarity between collections will be stated solely in terms of the numerical indexes themselves.

Evaluation of the Artifact Collections: Sample Size and Sampling Techniques

A problem of consequence is the evaluation of the reliability of the artifact collections. In an orthodox sense they are samples of the various periodized site deposits, which can be viewed as parent populations. It is important to determine whether they are reliable reflections of the qualitative and quantitative composition of their populations. This is always a difficult job to come to grips with in archeology, but one which is nevertheless commanding of attention. It is a two-part problem, having to do first with sample size, and second, with sampling technique.

Quite a range in sample size occurs, with extremes of 27 and 359 (Appendix III). The important question is whether or not all these samples are of sufficient size to give honest proportional representation of the lithomorphic classes of the deposits from which they were drawn. Regrettably, there is no answer to this question, at least no good answer. According to laws of probability which relate to the differences of samples, many of the samples

FIGURE 14

Unordered matrix with indexes of agreement for the 20 artifact collections.

Lots:

1. Levi, Period I
2. Kyle, Period V
3. Smith, Period V
4. Smith, Period IV
5. Oblate, Period V
6. Oblate, Period IV
7. Oblate, Period III
8. Wunderlich, Period III
9. Wunderlich, Period II
10. Devil's Mouth, Period V
11. Devil's Mouth, Period IV
12. Devil's Mouth, Period III
13. Devil's Mouth, Period II
14. Devil's Mouth, Period I
15. Coontail Spin, Period IV
16. Coontail Spin, Period III
17. Coontail Spin, Period I
18. Centipede, Period III
19. Roark, Period V
20. Roark, Period III

Lots	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	200																			
2	22	200																		
3	30	116	200																	
4	42	43	56	200																
5	63	98	82	59	200															
6	63	45	32	60*	92	200														
7	41	29	19	48	56	123	200													
8	21	12	18	35	30	35	58	200												
9	48	26	14	44	49	69	63	46	200											
10	36	76	71	30	90	61	44	25	57	200										
11	43	40	30	46	70	98	91	36	62	102	200									
12	40	39	25	46	65	91	85	59	74	93	116	200								
13	42	34	18	35	38	57	35	29	62	79	49	86	200							
14	105	21	23	41	58	64	45	35	68	48	63	56	50	200						
15	81	21	19	36	72	121	100	38	70	55	89	74	39	84	200					
16	68	24	24	35	66	95	56	65	82	49	61	95	88	80	98	200				
17	74	13	16	22	51	45	33	33	52	34	39	42	38	116	88	89	200			
18	69	32	14	40	60	69	60	50	50	35	49	64	41	62	81	118	58	200		
19	57	78	82	53	107	70	57	33	45	99	70	64	36	47	62	61	44	64	200	
20	41	22	26	34	51	43	51	58	36	53	69	68	37	31	62	89	37	104	89	200

* *Erratum*: the index of agreement for collections 4 and 6 is 50 instead of 60; this error was noted after the computer ordering of the matrix and could not be corrected.

are too small to be used in quantitative comparison. Yet non-random patterns exist in the data, as will be seen later on. The presence of these patterns is thus difficult to account for. There is another aspect to the evaluation of sample size which might throw light on the problem. With a small site, where small samples of the periodized deposits (populations) are collected, a sample of 60 artifacts may be more representative of its parent population than a collection of 400 artifacts from a larger site with many more artifacts. Unless it is somehow possible to determine or at least estimate the size of the populations, it is difficult to evaluate sample size. Since most of the Texas sites with small samples are comparatively small in extent, it is possible that most of the samples (the 20 collections) are of suitable size.

The ability of the samples to mirror their populations can be influenced by the sampling technique used in collecting them. This matter is entirely separate from the problem of evaluating sample size. When a population is finite but its composition is unknown, the proportions of observations (lithomorphic classes, in this instance) in the sample can be used to infer the appropriate proportions in the populations if the sample is randomly drawn.

The main condition which must be met if a sample is to be considered random is that it must be selected in a way which gives every observation in the parent population an equal chance of being included in the sample. Vescelius (1960), Binford (1964: 435), and Rootenberg (1964: 183) suggest ways in which random sampling can be approximated at archeological sites. Their approach is to deal with the sampling of excavation units, not individual artifacts. By and large, their recommendation for sampling middens consists of laying off the surface of a site in equal units such as one-meter or five-foot squares. One of the units is then selected from a table of random numbers, and others are chosen for excavation in terms of a predetermined, regular interval, or are selected from tables of random numbers. Vescelius, Rootenberg, and Binford make one error, however. Their methods view a site as a plane—a surface area—and it is sampled accordingly. But a site should be treated as a unit of volume. The deposits of many midden sites are lenticular in shape, and the problem of sampling cannot be conceived as a systematic or random placement of excavation units on a surface area. The proposed techniques could over-sample the margins of such a lense, and slight the central area. The whole problem of site sampling is complex and has not been adequately treated by anyone.

The lack of systematic sampling procedures at the Texas sites is obvious, and is one of the major deficiencies which ought to be corrected in future work. The need for such sampling methods arises from the possible lack of uniform horizontal distribution of artifact forms. The total *size* of the samples, the excavation units, acquired from the Texas sites cannot be estimated accurately since figures on midden volume are lacking. Only a rough approxi-

mation of sample size (in terms of per cent of the parent population sampled) can be given, expressed as a given portion of the surface of each site. The imprecision of this view of sampling has already been commented on, but it is better than nothing.

Roark Cave has a surface area of approximately 1,500 square feet (Kelly 1963: Fig. 4). Twelve five-foot squares were excavated, or approximately 20 per cent of the surface area. This may provide a relatively large sample of the site, but one which is not very evenly distributed. Seven pits were dug in the east-central area of the rockshelter, four in the west-central. Since the site is a small one, however, and since two separate areas were excavated, the sampling procedure followed at Roark Cave could have been worse.

Centipede Cave has a total surface area of about 1,475 square feet (Epstein 1963: Fig. 3), of which approximately 45 per cent was excavated. Both the eastern and western halves of the site were sampled. The size of the sample is large, and the distribution of the excavation pits over the surface area is wide.

The Coontail Spin Rockshelter (Nunley and Duffield MS) is a large rockshelter whose precise surface dimensions are not available. Apparently, however, less than 10 per cent of the area was excavated. The excavated portion of the site used in the present analysis is situated in the western end of the shelter.

The Devil's Mouth Site is a large, deep river terrace, the extent of whose occupational deposits has not been estimated (Johnson 1964: Fig. 2). In excavating Areas A and B of the site, however, I believe that the area of intensive occupation was almost completely excavated. If so, the artifact sampling procedure may be viewed as adequate. On the other hand, there may be other areas of debris accumulation, of which we have no inkling, buried deep within the terrace.

The Wunderlich Site has an estimated surface area of 1,500 square feet, of which about 22 per cent was excavated (Johnson 1962a: Fig. 2). The excavation squares were irregularly scattered over the areas of extensive occupation debris.

No exact surface dimensions are available for the Oblate Rockshelter. The site deposits extend lengthwise beneath the rockshelter overhang and for an undetermined distance out into the alluvial deposits in front of the shelter mouth. However, the deposits in the shelter proper constitute the main occupational materials, and about 75 per cent of this surface area was excavated (Tunnell 1962: Fig. 31). Only small portions of the northern and southern extremities of the rockshelter were not sampled. Considering the huge surface area which was excavated, the Oblate Rockshelter samples may provide relatively accurate representations of the total site composition.

Only the eastern and westernmost portions of the large Levi Rockshelter

were excavated (Alexander 1963: Fig. 1). The surface sampling procedure is deficient because the whole central surface area was untouched. Although only approximate surface dimensions were recorded, it is estimated that roughly 10 per cent of the site was dug.

The Smith Rockshelter has a total surface area of 1,700 square feet, of which approximately 28 per cent was excavated (Suhm 1957: Fig. 2). Although the excavated area is large, all the excavated squares were located in the southern half of the site.

The major occupation area of the Kyle Site was almost completely excavated (Jelks 1962: Fig. 3). Only the northern and southern fringes of the site were not sampled. Since 75 to 80 per cent of the 1,600 square feet of surface was excavated, the sampling procedure followed at the Kyle Site should produce very acceptable results.

From the foregoing it can certainly be seen that none of the nine sites from central and southwestern Texas was sampled in a systematic manner. If we consider only the problem of sampling surface areas, the excavations carried out at Centipede Cave, Roark Cave, the Devil's Mouth Site, the Wunderlich Site, the Oblate Rockshelter, and the Kyle Rockshelter may have produced relatively accurate reflections of the total site contents. The techniques followed in excavating the Coontail Spin Rockshelter and the Smith and Levi rockshelters are less acceptable. For all that, there is no recourse at present but to treat the artifact samples, the 20 collections, *as if* they were adequate samples in all respects. In support of this apparently libertine conduct, (but not as an excuse for the poor sampling techniques which I and others have followed) I want to emphasize again that the Texas midden sites, with a few exceptions like the Coontail Spin Rockshelter, are comparatively small sites. There may be little difference in the horizontal distributions of their artifact forms, certainly not the great variation in horizontal occurrence which exists in large, multi-component village sites. Normally, the horizontal differences which have been recognized within Texas middens are the type accounted for by widely separated periods of site occupation. Hence I have less hesitation to treat the samples as adequate for purposes of this comparative study than I might otherwise, although in a strict sense the conclusions which are reached from these samples will need to be labeled as "tentative."

Ordering the Matrix

The indexes of agreement for all pairs of the 20 period artifact inventories are presented in Fig. 14. This is an unordered, unsorted matrix which will be analyzed in the way suggested by Kroeber (1940: 33). The matrix must be sorted so that similar indexes are next to each other in the rows and columns as already described. The top right-hand part of the matrix and the

lower left-hand half are mirror images of one another, and must be ordered simultaneously. Once the best possible ordering is achieved, the highest indexes along any row or column will be close to the diagonal. The index values will tend to diminish in magnitude in successive cells moving away from the diagonal.

A manual ordering board consisting of movable blocks of wood could be used to arrange the matrix. Boards are available at U. C. L. A. and the University of Queensland, Australia, but they are not practical for comparing numerous collections because of the great amount of time which their manipulation takes. They are effective, however, when working with a small number of site collections. A large computer can arrange a complex matrix in short order, and is a great time saver. Three computer programs have already been worked out by the Aschers (1963), Kuzara and Dixon (verbal communication, 1965), and Clarke (1962).

The matrix ordering of the data in Fig. 14 was carried out according to the computer program developed by Richard S. Kuzara of Santa Monica, California, and Keith A. Dixon and George R. Mead of California State College at Long Beach.* The indexes were recorded on coded punch cards and submitted to Western Data Processing Center at the University of California, Los Angeles. The IBM 7094 computer at Western Data Processing Center was used to sort the matrix,, a process which involved a total computer time of approximately 10 minutes. Fig. 15 gives the final matrix as it was ordered by the computer.

Index Patterning

Once the matrix has been ordered, it is possible to discern patterns in the arrangement of the indexes. The first pattern which emerges is the linear succession of collections along the diagonal, which is repeated at the top and left edge of the matrix (Fig. 15). This is a general statement of the resemblance of the collections to each other in terms of a similarity continuum expressed as a straight line. Artifact collections which are close to one another along this diagonal are more similar than collections which are farther apart. If the matrix ordering were being done to seriate collections temporally, this linear arrangement of the collections would represent their relative placement in time. However, the dates of the 20 collections have already been determined, and the differences between their indexes cannot be ascribed to temporal variation alone.

Nevertheless, the linear succession of the collections does prove that

* Richard S. Kuzara is a computer programmer for Systems Development Corporation of Santa Monica. This program was written during 1965, in FORTRAN IV language, and is in Mr. Kuzara's personal files.

FIGURE 15

Matrix ordered by computer

Lots:

1. Levi, Period I
2. Kyle, Period V
3. Smith, Period V
4. Smith, Period IV
5. Oblate, Period V
6. Oblate, Period IV
7. Oblate, Period III
8. Wunderlich, Period III
9. Wunderlich, Period II
10. Devil's Mouth, Period V
11. Devil's Mouth, Period IV
12. Devil's Mouth, Period III
13. Devil's Mouth, Period II
14. Devil's Mouth, Period I
15. Coontail Spin, Period IV
16. Coontail Spin, Period III
17. Coontail Spin, Period I
18. Centipede, Period III
19. Roark, Period V
20. Roark, Period III

Lots	3	2	10	19	5	6	7	11	12	13	9	20	18	16	15	14	17	1	4	8
3	200	116	71	82	82	32	19	30	25	18	14	26	14	24	19	23	16	30	56	18
2	116	200	76	78	98	45	29	40	39	34	26	22	32	24	21	21	13	22	43	12
10	71	76	200	99	90	61	44	102	93	79	57	53	35	49	55	48	34	36	30	25
19	82	78	99	200	107	70	57	70	64	36	45	89	64	61	62	47	44	57	53	33
5	82	98	90	107	200	92	56	70	65	38	49	51	60	66	72	58	51	63	59	30
6	32	45	61	70	92	200	123	98	91	57	69	43	69	95	121	64	45	63	60	35
7	19	29	44	57	56	123	200	91	85	35	63	51	60	56	100	45	33	41	48	58
11	30	40	102	70	70	98	91	200	116	49	62	69	49	61	89	63	39	43	46	36
12	25	39	93	64	65	91	85	116	200	86	74	68	64	95	74	56	42	40	46	59
13	18	34	79	36	38	57	35	49	86	200	62	37	41	88	39	50	38	42	35	29
9	14	26	57	45	49	69	63	62	74	62	200	36	50	82	70	68	52	48	44	46
20	26	22	53	89	51	43	51	69	68	37	36	200	104	89	62	31	37	41	34	58
18	14	32	35	64	60	69	60	49	64	41	50	104	200	118	81	62	58	69	40	50
16	24	24	49	61	66	95	56	61	95	88	82	89	118	200	98	80	89	68	35	65
15	19	21	55	62	72	121	100	89	74	39	70	62	81	98	200	84	88	81	36	38
14	23	21	48	47	58	64	45	63	56	50	68	31	62	80	84	200	116	105	41	35
17	16	13	34	44	51	45	33	39	42	38	52	37	58	89	88	116	200	74	22	33
1	30	22	36	57	63	63	41	43	40	42	48	41	69	68	81	105	74	200	42	21
4	56	43	30	53	59	60	48	46	46	35	44	34	40	35	36	41	22	42	200	35
8	18	12	25	33	30	35	58	36	59	29	46	58	50	65	38	35	33	21	35	200

temporal fluctuations in artifact classes and their frequency are very important in accounting for the varying composition of the artifact collections. Thus the positions of the collections along the diagonal partially agree with what is already known about their relative ages. Period V collections cluster together at the upper left-hand extreme of the diagonal, while collections of Period I are found toward the opposite end. Periods II, III, and IV are mixed together along the center of the line.

Alfred L. Kroeber (1940: 34, Fig. 5) has used one of the most intelligible formats in archeology for showing the patterning of matrix values and this technique, whose antecedents go back some 60 years, will be followed here. An ordered matrix is treated, first, by labeling a certain range of values (indexes) as "high" and indicating their location on the matrix by black squares. Successively smaller indexes are indicated by other symbols and their locations are also plotted on the matrix. Next, where relatively high indexes cluster together along the diagonal *in the form of a square,* a line is drawn about them to show that they represented a cohesive group of values. The sites which produce the high values of a single square constitute a single cluster. It is necessary that a group of high indexes, a cluster, produce a square outline for only when this condition is met do the collections *all* share high values and form a consistent pattern.

Fig. 16 shows the patterning of the indexes among the 20 collections. Black symbols stand for "high" indexes of 80 and above, while shaded symbols represent the "intermediate" range of 70 through 79. All indexes below 70 are considered "low" and do not appear on the matrix of Fig. 16. These values were settled on after considerable experimentation with different figures. They set rather arbitrary boundaries, but produce the best patterning of the data. Of course, "high" does not refer to any absolute value that would be appropriate for all possible sets of data which might be compared. If a group of extremely similar collections were examined, 80 or 85 might well be a "low" value for an index. As Kroeber made clear,

> . . . for this reason there can be no rule about the range of values to be denoted by one symbol in the graphic representation. One is free to choose as many or as few symbols as one likes, and to assign to each any value-range that will bring out the salient lines of the grouping (Kroeber 1940: 35).

That patterning of the relatively high values can now be discerned, and the technique of isolating suqare-shaped clusters of high indexes can be applied. Fig. 17 shows six clusters, A through F, which include three or more collections sharing similarly high indexes of agreement. The requirement has been set that clusters of three collections, or nine symbols, should all have "high" indexes. In delimiting clusters with four or more collections, "intermediate" values have also been allowed. Clusters E needs to be ex-

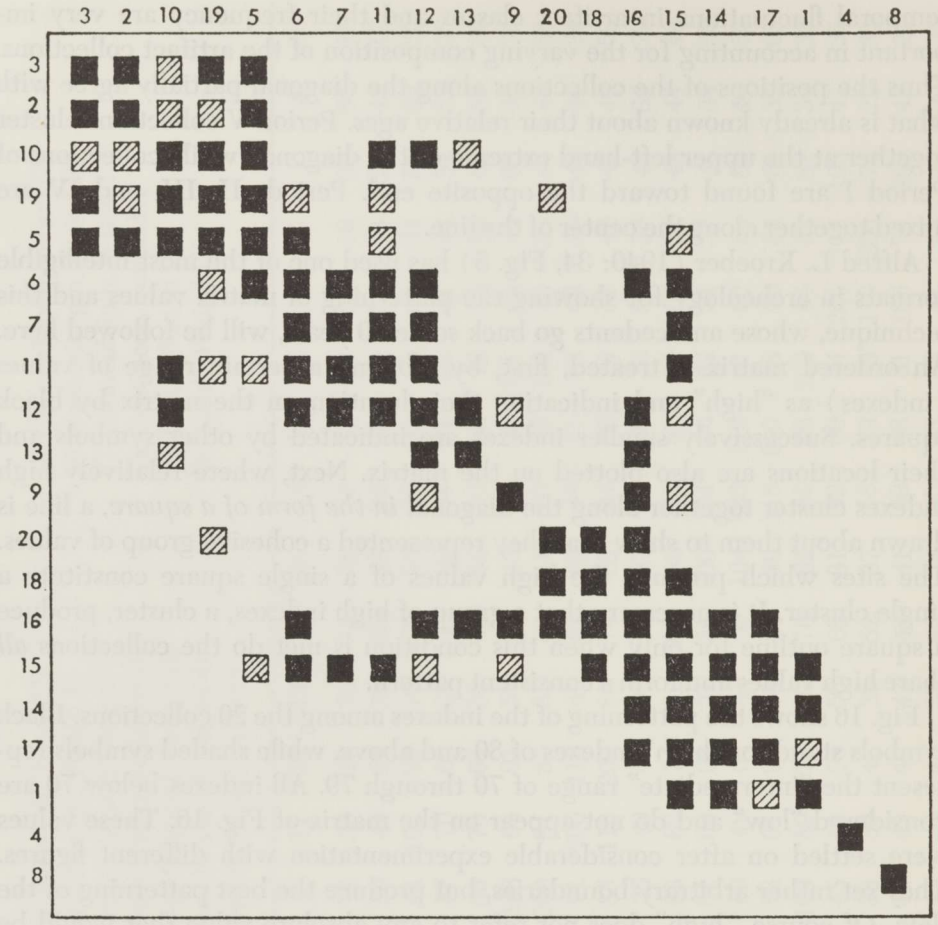


FIG. 16. Classification of index values within the matrix. Black squares, high values of 80 and above; hatching, intermediate values of 70 through 79.

plained since it is the only one of the six index clusters which appears not to have a square outline. It consists of a block of indexes for collections 6, 7, 11, and 12, and another, separate, group of indexes for collection 15 (Fig. 17). This disjointed arrangement occurs because collection 15 is part of four clusters: A, B, C, and E. Since all its indexes of agreement must remain on one line, the computer had to place collection 15 either near cluster E or with the other clusters at the other end of the diagonal; it could not be divided. This explains the graphic division of cluster E in the matrix. In fact, it is a true cluster composed of collections 6, 7, 11, 12, and 15.

The six index clusters of Fig. 17 are the major patterns which emerge from the matrix study, and around which several observations and cultural in-

terpretations can be framed. Before going on to an analysis of the clusters, however, more should be said about the nature of the matrix itself.

One of the beauties, and at the same time one of the disadvantages, of the matrix method of comparison is that it shows relationships in the form of a continuum. In this respect it is a very exact comparative tool. However, precisely for this reason it is also a difficult tool to use since the ordinary goal of comparison is classification in terms of exclusive units or categories. This aspect of classification is incompatible with matrix ordering. The isolation of clusters within the matrix seen in Fig. 17 is a compromise classification where the continuum has been cut up into several units, but units which are not necessarily exclusive. Clusters A, B, C, D, and E overlap considerably. Overlapping provides a more accurate picture of the plexus of data relationships

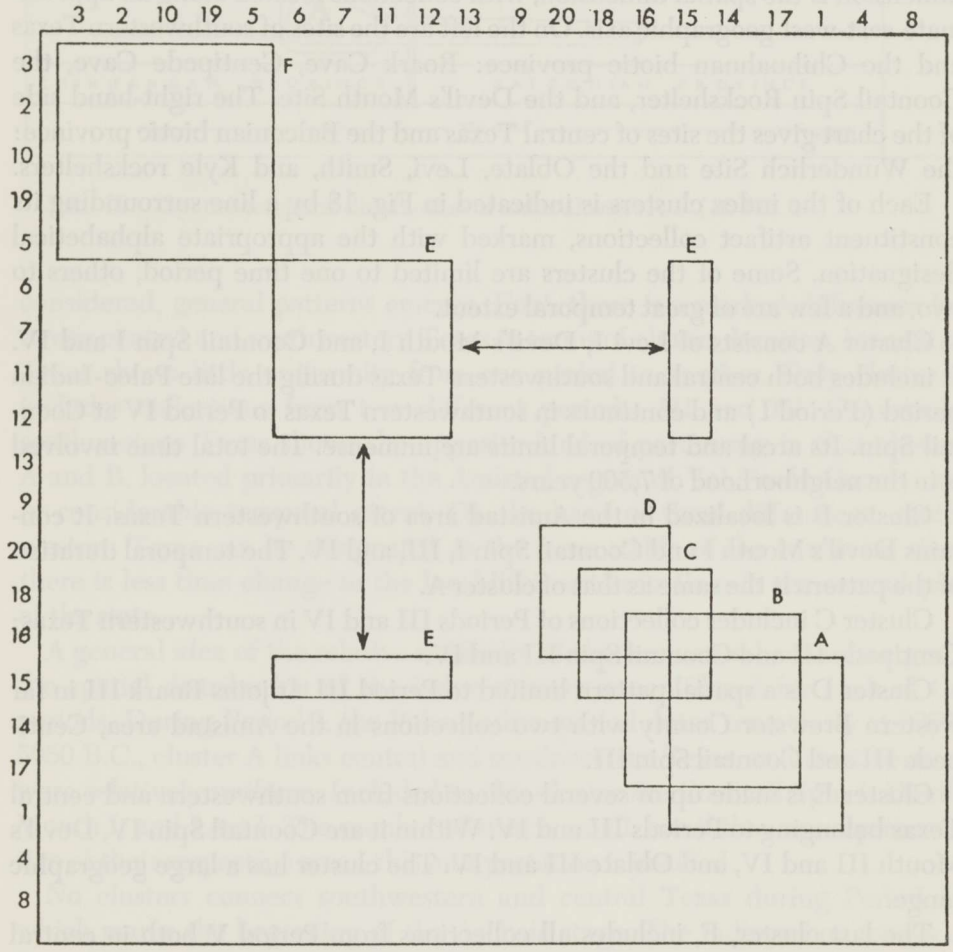


FIG. 17. Index clusters, A through F.

than exclusive unit definition, and is thus more compatible with the matrix continuum.

Spatial-Temporal Distribution of the Index Clusters

The six index clusters of Fig. 17 are composed of artifact collections of various periods and sites. Fig. 17 demonstrates their interrelationships satisfactorily, but says nothing about the real distributions of the patterns. It is now necessary to plot each index cluster in time and space.

Fig. 18 represents the spatial-temporal occurrence of each of the six index clusters. The vertical dimension of the chart is the time dimension, with artifact collections placed in accord with the five major periods. The horizontal dimension is the spatial dimension, with collections located along an approximate east-west geographic axis. On the left are the sites of southwestern Texas and the Chihuahuan biotic province: Roark Cave, Centipede Cave, the Coontail Spin Rockshelter, and the Devil's Mouth Site. The right-hand side of the chart gives the sites of central Texas and the Balconian biotic province: the Wunderlich Site and the Oblate, Levi, Smith, and Kyle rockshelters.

Each of the index clusters is indicated in Fig. 18 by a line surrounding its constituent artifact collections, marked with the appropriate alphabetical designation. Some of the clusters are limited to one time period, others to two, and a few are of great temporal extent.

Cluster A consists of Levi I, Devil's Mouth I, and Coontail Spin I and IV. It includes both central and southwestern Texas during the late Paleo-Indian period (Period I) and continues in southwestern Texas to Period IV at Coontail Spin. Its areal and temporal limits are immense. The total time involved is in the neighborhood of 7,500 years.

Cluster B is localized in the Amistad area of southwestern Texas. It contains Devil's Mouth I and Coontail Spin I, III, and IV. The temporal duration of the pattern is the same as that of cluster A.

Cluster C includes collections of Periods III and IV in southwestern Texas: Centipede III and Coontail Spin III and IV.

Cluster D is a spatial pattern limited to Period III. It joins Roark III in far western Brewster County with two collections in the Amistad area, Centipede III and Coontail Spin III.

Cluster E is made up of several collections from southwestern and central Texas belonging to Periods III and IV. Within it are Coontail Spin IV, Devil's Mouth III and IV, and Oblate III and IV. The cluster has a large geographic range.

The last cluster, F, includes all collections from Period V both in central and southwestern Texas. It is basically a spatial pattern.

When the temporal and spatial distributions of all the index clusters are

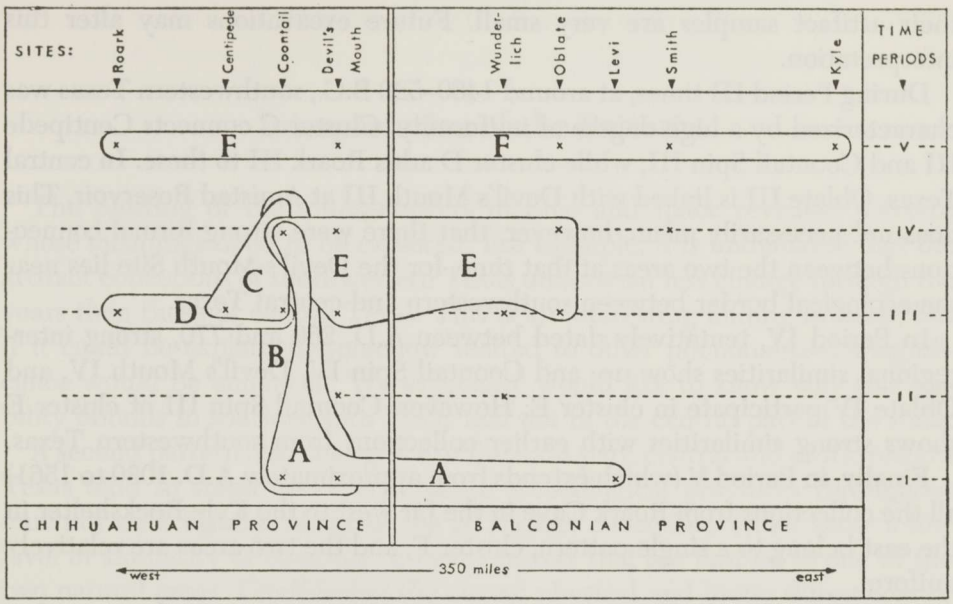


FIG. 18. Spatial-temporal distribution of index clusters A-F (cf. FIG. 17).

considered, general patterns emerge. First, there is a marked difference between central and southwestern Texas in terms of cluster duration, for central Texas shows little uniformity from one period to another. Only cluster E includes collections from two different periods: III and IV. Conversely, southwestern Texas shows the opposite kind of patterning in that clusters A and B, located primarily in the Amistad region of Val Verde County, are of considerable temporal extent. On the basis of these differences, southwestern Texas can be designated as the more stable of the two areas since there is less time change in the local lithic artifacts than in the central part of the state.

A general idea of the relative similarity of the two natural areas emerges if the spatial distribution of the index clusters is considered for each of the periods. During Period I, the Paleo-Indian period dated tentatively at 8050–5950 B.C., cluster A links central and southwestern Texas, and the two areas were relatively uniform. Included in this cluster are Coontail Spin I, Devil's Mouth I, and Levi I. The number of sites is small, but if they are representative of their respective areas, this interpretation is justified.

No clusters connect southwestern and central Texas during Period II, which marks the beginning of the Archaic stage. The radiocarbon assays of Period II group at around 6730–2630 B.C. However, only two site collections, Devil's Mouth II and Wunderlich II, are available for this long interval, and

their artifact samples are very small. Future excavations may alter this interpretation.

During Period III times, at around 1460–520 B.C., southwestern Texas was characterized by a high degree of uniformity. Cluster C connects Centipede III and Coontail Spin III, while cluster D adds Roark III to these. In central Texas, Oblate III is linked with Devil's Mouth III at Amistad Reservoir. This does not necessarily mean, however, that there were strong formal connections between the two areas at that time, for the Devil's Mouth Site lies near the ecological border between southwestern and central Texas.

In Period IV, tentatively dated between A.D. 260 and 770, strong interregional similarities show up, and Coontail Spin IV, Devil's Mouth IV, and Oblate IV participate in cluster E. However, Coontail Spin III of cluster E shows strong similarities with earlier collections from southwestern Texas.

Finally, in Period V (which extends from approximately A.D. 1030 to 1561) all the collections from Roark Cave in the far west to the Kyle Rockshelter in the east belong to a single pattern, cluster F, and the two areas are relatively uniform.

From the above, and from an inspection of Fig. 18, it can be seen that there is a tendency for the two natural areas to stand apart. Many of the artifact collections of central Texas fail to form clusters, and in southwestern Texas there are three clusters (B, C, and D) limited entirely to that area. The major exception to this pattern is the relative uniformity of central and southwestern Texas in Periods I, IV, and V.

Interpretation of the Patterns

The plotting of the index clusters in time and space revealed patterns whose meanings need to be explored. For example, it is undeniable that the artifact collections of southwestern Texas underwent less change through the years than those of central Texas. This is an interesting finding in itself, but if it could be explained—somehow related to other phenomena—its significance would be enhanced. We especially would like to know why this stability obtains in southwestern Texas and not in the central part of the state.

A second pattern also emerges. For the most part, central and southwestern Texas tend to stand apart as separate archeological provinces throughout much of their history. Many of the 20 artifact collections either show a low level of similarity or combine to form clusters that are limited to one of the two natural areas. Considering the strong physical and biotic differences of the two regions, this is not surprising. What is surprising, however, are the exceptions to this rule. During Periods I, IV, and V, index clusters cut across the ecological boundary and bind collections from southwestern and central Texas closely together. Why this should occur during these periods forms a perplexing question.

Environment and Conservatism

What factors operated in the past to cause the great temporal duration of index clusters A and B in the Amistad area of southwestern Texas? The time span involved is about 7,500 years, and extends from Period I through Period IV. In contrast, central Texas shows little temporal stability in the composition of its lithic artifact collections.

The social structure, political organization, and culture values of the local people may have had their effect on this differential patterning, but this information is hopelessly lost. Knowledge about the general ecology of the two areas is accessible, however, and is pertinent to the problem at hand. It is suggested that the temporal uniformity found in southwestern Texas and not in central Texas is a result of the differential effects of environment and geographic location on the material culture of the people who lived in these areas. There are three hypotheses which might explain their effect.

Hypothesis I. One possible explanation is that a simple but efficient economic adjustment to the harsh southwestern desert was achieved at an early date. Because of the limited resources of the area, there would be little possibility for economic change so long as the economy was based on hunting and

gathering. Thus, if a successful adaptation were made which involved a utilization of the major food sources, change in the economy would not be anticipated. This stability would be mirrored in the temporal uniformity of the artifact collections if the variation in artifact forms were a reflection of their different functions.

It is true that the area is austere and its resources are scanty, at least in comparison with central Texas. Southwestern Texas has a low rainfall which amounts to only 15 inches or less yearly, and the surface water is more limited than in central Texas both in quantity and distribution. The Pecos, Rio Grande, and Devil's River furnish the only permanent supply. Also, the Chihuahuan biotic province (Dice 1943; Blair 1950) offers less in the way of vegetal resources than central Texas. Desert plants such as sotol, agave, and yucca provide foodstuffs of high bulk and low food value. In addition, the small game animals of the area do not compare with the rich protein resources, the abundant ruminants, of central Texas.

The available faunal and floral data from archeological sites in southwestern Texas agree with the expectations generated from a consideration of the local desert environment. These data suggest that land and stream gathering (of burrowing rodents, reptiles, land snails, shellfish, etc.) and small game hunting were the primary economic activities of southwestern Texas in Archaic times. Table 3 gives the rank-order of remains from Centipede Cave (Lundelius 1962: 127–129), the Devil's Mouth Site (Johnson 1964: 79–80), Eagle Cave (Dee Ann Story, written communication, 1965), and Coontail Spin Rockshelter (*ibid.*).

The Devil's Mouth Site (Table 3) provides the only known indication that deer were ever taken in large numbers in the southwestern part of the state. However, since this site is located near the border between the two natural areas, it is not as typical of southwestern Texas as Centipede Cave and other sites found further to the west. The only known hint at the practice of hunting big game is the single Archaic bison kill at the Bonfire Site (C. D. Tunnell, personal communication, 1964). Bison bones are rare in any occupation site in southwestern Texas.

Central Texas is a more varied land, with relatively rich food and water resources. It has a comparatively heavy annual rainfall which averages between 30 and 35 inches. There is an abundant, evenly distributed supply of water in rivers, small tributary streams, and thousands of artesian springs. The Balconian biotic province (Blair 1950) is characterized by a variety of abundant vegetation and large numbers of game animals, especially whitetail deer, and in lesser numbers, bison (before 1840). Thus the semi-wooded hills and valleys of the Edwards Plateau seem to offer a varied environment for hunting and gathering people. In contrast to southwestern Texas, the

TABLE 3

Rank-order of major Archaic faunal and floral remains from four southwestern Texas sites
(most abundant form at top of each list)

Coontail Spin:	Eagle Cave:	Centipede Cave:	Devil's Mouth:
1. honey mesquite	1. scrub live oak (acorns)	1. Florida cottontail	1. fish
2. Texas walnut	2. Texas walnut	2. pack rat	2. deer
3. shin oak (acorns)	3. Mexican buckeye	3. jackrabbit	3. jackrabbit
4. mountain laurel	4. Honey mesquite	4. desert cottontail	4. desert cottontail
5. little leaf leadtree	5. yucca	5. ground squirrel	5. soft-shelled turtle
6. yucca	6. nopal cactus	6. black squirrel	6. cotton rat
7. guajillo	7. mountain laurel	7. cotton rat	7. birds
8. Mexican buckeye	8. persimmon	8. ring-tail cat	8. wood rat
9. persimmon	9. little leaf leadtree	9. soft-shelled turtle	9. pocket gopher
10. hackberry	10. blackbush acacia	10. deer	(plus untabulated but abundant remains of snail and mussel)
11. blackbush acacia		11. snakes	
12. sunflower		(plus untabulated but abundant remains of fish and snails)	
13. wild onion			
14. twoleaf senna			
15. agave			
16. scrub live oak (acorns)			
17. nopal cactus			

central area has a potential for different economic emphases even within a framework of a mixed hunting-gathering economy.

The faunal remains from the known sites of central Texas show that, in addition to the economic activities of southwestern Texas, intermediate game hunting (deer, antelope, etc.) and large game hunting (bison) were quite important. With this wider scope of economic pursuits different parts of the environment could theoretically be emphasized at different periods (ruminants, small game, seeds and nuts, etc.) and exploitation could shift from one economic activity to another. Southwestern Texas does not have this potential for economic variability. Unfortunately, the necessary controls are not available which would allow us to trace economic changes from period to period. The following faunal and floral data, on which the economic activities of central Texas were postulated, belong certainly to the Archaic even though specific period assignments within the Archaic cannot be made.

Seven sites in central Texas have published faunal descriptions, and there is one with classified plant remains. The likelihood of differential preservation has to be kept in mind in comparing the two areas, since the more humid climate of central Texas may partially explain the paucity of the small bones of rodents.

TABLE 4

Rank-order of major faunal and floral remains from two central Texas sites (most abundant form at top of each list)

Oblate Rockshelter	Kyle Rockshelter	Kyle Rockshelter
1. deer	1. deer	1. sunflower
2. fish	2. snakes	2. wild onion
3. terrapin	3. pine vole	3. oak (acorns)
4. snakes	4. cotton rat	4. pecans
5. soft-shelled turtle	5. birds	5. cocklebur
6. bison	6. pocket mouse	6. gourd (wild)
7. fox	7. cottontail	
8. skunk	8. turtle	
9. birds	9. frogs	
10. coyote or wolf	10. fish	
11. beaver	11. gopher	
12. rat	12. beaver	
	13. coyote	
	14. pack rat	
	15. bison	
	16. grasshopper mouse	
	17. badger	
	18. antelope	
	19. soft-shelled turtle	

At the Footbridge Site (Suhm 1962: 73) the few bones which could be identified include deer, bison, and turtle, in that order of frequency. Snails and mussel shells were abundant. Better preserved and more abundant remains come from the Crumley Site (Kelly, 1961: 266). Here a large number of snail shells were recovered, and unspecified amounts of deer, bison, wolf, and coyote bones.

The Smith Rockshelter (Suhm 1957: 51–54) yielded large but uncounted numbers of snails, mussels, fish, turtles, birds, deer, bison, antelope, skunk, raccoon, opossum, coyote or wolf, cotton rat, pack rat, cottontail, and beaver. The Oblate Rockshelter (Tunnell 1962: 114, Table 9) and the Kyle Rockshelter (Jelks 1962: 111–112, Tables 4 and 5) produced relatively large samples of tabulated faunal and floral remains which are listed in their rank-order in Table 4. The importance of deer and the presence of bison can be seen.

To return to hypothesis I, we can postulate that the mixed hunting-gathering economy of southwestern Texas with its emphasis on land and stream gathering and small game hunting was a successful system in an area with little potential for other economic activities. Hence with no major economic change, there would be no major change in tool forms if the forms of the tools were related strictly to their function.

Central Texas had a more varied series of economic activities, which included the hunting of both intermediate and large game animals. Whether there were shifts in the economy during the Archaic or not, we simply do not know, but at least the potential for such change was there. If this did occur, then it could help explain the lack of temporal uniformity in the artifact collections if the variation in artifact forms were a result of their use in different economic activities. This point cannot be answered.

Hypothesis II. The temporal changes in artifact collections may not reflect functional changes in the lithic artifacts as suggested above, but rather stylistic changes caused by influences from other areas, or by actual immigrations. Marked differences in the composition of collections from different periods could result from intense outside contacts, while a lack of such differences would indicate a minimum of outside influences. It can be postulated that southwestern Texas was less susceptible to outside contacts than central Texas because of its more stringent environment. The restricted water and food supply would be less likely to attract immigrants or to encourage outside influences than the more abundant resources of central Texas. Hence the greater temporal stability of artifact collections in the southwestern part of Texas might reflect this lack of regional intercourse.

This explanation for the hypothesized temporal stability of southwestern Texas is based, in part, on the environmental interpretation of conservatism in northern Coahuila formulated by Walter W. Taylor in his paper, "Tethered

Nomadism and Water Territoriality" (1964). Regrettably, the exact region on which the article is based is never specified, and "northern Coahuila" is a large and rather diversified area. My impression, however, is that Taylor means the area just south of Amistad International Reservoir and north of Los Burros Mountains where he supervised reconnaissance work for the National Institute of Anthropology and History of Mexico (Taylor and González Rul 1961). This part of Coahuila lies directly across the Rio Grande from the Devil's Mouth Site, Centipede Cave, and the Coontail Spin Rockshelter, and is well within the Chihuahuan biotic province. The country is similar to the United States side of the Rio Grande with two exceptions. At high altitudes, the Los Burros Mountains have a floral assemblage of pine, oak, and grasses, and their northern foothills and *bajadas* are a dense *monte* of leguminous shrubs (mesquite, huizache, etc.) and desert succulents (agave, yucca, sotol, and nopal cactus). The U. S. side of the Rio Grande has a more typical desert vegetation which is much sparser than *monte*.

Taylor discovered that practically all habitation sites are situated at the mouths of canyons, the place where the mountains and the *monte* of the low foothills come together. This settlement pattern reflects a compromise between two types of natural environments, the food-giving *monte* and the water-giving mountains. The aboriginal people roamed the waterless *monte* in search of large quantities of crude vegetal food, while staying within traveling distance of the watered mountains. Taylor hypothesizes a kind of "water territoriality" for the people of northern Coahuila determined by ". . . the efficient distance of round-trip foot travel along radii extending in all directions from a point or points of socially preempted water" (Taylor 1964: 200).

Taylor relies on the above characterizations to explain the archeological evidence (which he fails to specify) for a remarkable cultural conservatism in northern Coahuila for at least 10,000 years. Influences from outside the area were practically non-existent, he maintains, because the pre-emption of water by small, local groups made it difficult for outsiders to stay in the area long enough to bring about any appreciable culture change. Although this may be true, I feel that Taylor's emphasis is misplaced. Outside influences would be minimal but mainly because the limited resources would be unattractive to peoples of rich areas.

Taylor's environmental explanation of conservatism in Coahuila could be used in a modified form to explain the temporal stability of artifact collections in nearby southwestern Texas. Water resources are more abundant in southwestern Texas than in northern Coahuila because of the three rivers, but otherwise the areas are very much alike. The concentration of water in very limited areas in southwestern Texas (the river valleys) would limit population size as much as conditions prevailing in northern Coahuila. The

economy depended largely on small animals and large amounts of high-bulk desert plants with precious little food value. Since the local desert does not support the abundant ruminants of central Texas, protein resources were also low.

As a result of these features of the environment, the people who lived along the rivers of southwestern Texas would need large tracts of nearby land whose food sources could be relied on, and the size of any group would be restricted by the resources of the desert land which could be covered by round-trip travel from the living sites. The number of bands and the total population would be small since only the land near the rivers could be effectively exploited. The groups would be "tethered" to the rivers, and their mobility along the valleys would be restricted by the pre-emption of living sites and adjacent food territories. Thus the situation in southwestern Texas would be nearly identical to northern Coahuila with the exception that low population and isolation would be a function of the limited geographic distribution of water, not its limited supply. The scanty resources of both areas would offer little temptation to outsiders.

If this characterization is true, southwestern Texas should be as culturally insular and temporally stable as northern Coahuila, and certainly much more so than central Texas. This would help to explain the observed archeological conservatism. Conversely, the larger protein and carbohydrate resources of central Texas, as well as the more widely scattered water sources, should be more attractive to outsiders. These conditions would conceivably attract immigrants and encourage trading and social contacts with areas such as the adjacent Eastern Woodlands and the Great Plains. Such contacts, or influxes of new people, would help to explain the change in artifact collections in central Texas from one period to another. Temporal differences in tool forms might reflect successive occupations by different people, or local stylistic changes brought about by contacts with outsiders.

Hypothesis III. A third theory can be drawn up to explain differences in stability between southwestern and central Texas. The southwestern area of the state was probably not on the route of diffusion between areas of higher culture, whereas there is pretty good evidence that central Texas may have been. This idea is similar to hypothesis II, but maintains that southwestern Texas had few outside contacts and was conservative not necessarily because of its uninviting environment, but because it was far removed from major highways of diffusion. There are only a few data which directly support this idea, but they are suggestive.

J. Charles Kelley (1952) claims that there were two main routes of diffusion across inland Texas, along which ideas moved from Mexico into the Southeast. The "northern overland route" went, he hypothesizes, from Zacatecas and Durango down the Rio Conchos to the Rio Grande and thence

overland across the Edwards Plateau to the Mississippi Valley. It is known that an elaborate system of trade and diffusion—illustrated by the wanderings of the Jumano Indian, Juan Sabeata (Kelley 1955)—developed along the northern part of this route in late historic times. Central Texas would be influenced, but not southwestern Texas as defined in this paper.

A second route of diffusion, the "southern overland route," extended from Mexico northward across the Gulf Coastal Plain, striking the Edwards Plateau on the south and east, and running eastward then to the Mississippi River. Ethnographic data indicate that ". . . persons, things, and ideas actually traversed this route in the early historic period" (Kelley 1952: 140, 141). A lack of dependable food resources and their local and seasonal distribution encouraged an involved system of seasonal wandering by the Coahuiltecan bands of the Coastal Plain, and this aided diffusion across the area.

> During the winter the Mariames [a Coahuiltecan band] occupied the lower stretches of the river [Colorado or Guadalupe], living on rats, snakes, insects, dung, powdered bone, roots, and anything else that was even near-edible. This was the real starvation time. In the spring the river overflowed and fish were caught in the overflow pools, furnishing for some weeks a new source of food. As the early summer came on, the group moved slowly down the river toward the coast, eating green *Tunas*, berries, roots, and small game. They then turned southward toward Mexico and followed the coast for some thirty leagues, subsisting *enroute* by killing "deer" . . . perhaps antelope—by running them into the sea (Kelley 1952: 142).

The extensive wandering habits of the Mariames and many other Coahuiltecans made possible the diffusion of ideas, personnel, and trade products along the southern overland trade route. Probably the pattern extended back into prehistoric times as well. Once again, as in the case of the northern overland route, parts of central Texas would be included and southwestern Texas would be isolated from the influences of diffusion.

In addition to the fact that southwestern Texas was not situated in a suitable geographic area to be included in these routes, the lack of widely scattered water sources would hinder travel across the area. Whereas the seasonal movement of the Coahuiltecans on the well-watered Coastal Plain adjacent to central Texas lent itself to disseminating cultural items, the "tethered nomadism" which may have prevailed in southwestern Texas would work against diffusion.

The foregoing hypotheses have been offered in an attempt to explain the possible impingement of environment and geographic location on the conservatism of southwestern Texas and the more marked change of artifact collections in central Texas. It is not possible now to say which, if any, of the hypotheses are true. All three may be partially or wholly correct since they are not mutually exclusive. Although a final solution cannot be agreed on,

the fact that these problems have been recognized and can be pinpointed for additional research shows the possible utility of the quantitative comparison of the artifact collections.

Future investigation should be able to evaluate the three hypotheses. A determination of the precise function of the various artifact forms could be used to evaluate hypothesis I. Such a study should show whether or not there have been changes in the economic activities of central Texas which would explain the lack of temporal continuity in the artifact collections there. Also, a careful study of the relative abundance of the organic indicators of economic pursits from future excavations might show temporal shifts in the popularity of certain economic activities. Research into the ethnographic data in the early Spanish and American documents might yield new information about the intensity of contact between central Texas and other areas and would throw light on hypotheses II and III. Both lines of investigation would call for a concerted effort, but they would surely be worth the pains. It is hoped that researchers working in the two areas will keep these problems in mind and apply pertinent information to their solution as it becomes available.

Similarities between Central and Southwestern Texas

The distribution of index clusters in Fig. 18 shows that central and southwestern Texas can be regarded as separate archeological provinces although they are linked by index clusters at some periods. This agrees basically with Suhm and others (1954), who have separated central from "Trans-Pecos" Texas (southwestern and western Texas) on the basis, mainly, of the geographic occurrence of specific artifact types. We know, however, that similar stem forms (periods markers) are found in both areas and that some contact between them must have occurred.

Figure 18 shows this areal distinction in a more graphic way than has been possible before. Several marked differences in the behavior of the indexes in the two areas have been pointed out. One is the temporal continuity of clusters in southwestern Texas, which does not occur in central Texas. Also, there is a regional distinction between the areas which, however, has its exceptions. Thus there are major ties between central and southwestern Texas during Periods I, IV, and V. Why the two areas are more similar at these times than at others forms an interesting question, but one which cannot be answered satisfactorily. A few tentative explanations are offered below, but they are hypothetical in the extreme. Speculation, however, has an heuristic value.

I suggest that the uniformity of Period I is simply a manifestation of the general homogeneity of Paleo-Indian materials over broad areas. Lacking

quantitative comparisons of numerous Paleo-Indian sites, this is a difficult assertion to justify, but it is offered as a possible explanation of the similarity of central and southwestern Texas during Period I. This uniformity has been recognized in other areas through a nonquantitative comparison of artifact collections, for instance in the Eastern Woodlands (Caldwell 1958).

It is difficult to decide if Levi I, Devil's Mouth I, and Coontail Spin I should actually be called "Paleo-Indian" or "Lithic" using the economic definition of Willey and Phillips (1958). Were the people who occupied these sites actually specialized hunters of late Pleistocene herbivores? It is not known for certain, but the faunal remains from the Levi Rockshelter (Alexander 1963: 514, Table 1) tend to answer the question negatively. Land and stream gathering, as well as small and intermediate game hunting, seem to have been the dominant economic activities, although a few large herbivores were also killed. This mixed hunting-gathering economy is identical for practical purposes with that of the subsequent Archaic.

One alternative is to consider the Period I sites "transitional" between the Paleo-Indian and Archaic stages in Texas, although they still had strong stylistic ties (such as lanceolate projectile points) with earlier Paleo-Indian materials. This interpretation is supported by the available radiocarbon assays which place Period I between 8050 and 5950 B.C., ending about the time of the final disappearance (at around 6000 B.C.) of the camel, horse, large bison, and elephant (Hester 1960). The change in transitional Paleo-Indian times toward collecting and hunting small game is hinted at in other areas of North America such as the Allen and Long sites of the northern Great Plains (Alexander 1963: 526). At the Ray Long Site of South Dakota, grinding stones were found in apparent association with lanceolate points (*Angostura* type), although no faunal remains survived. At the Allen Site in Wyoming, grinding stones, fish hooks, and a varied fauna including small game animals were recovered.

Since the Period I sites may be transitional, both temporally and in economic pattern, between the Paleo-Indian and Archaic, it is possible that they represent a common base out of which the later Texas Archaic cultures developed. This might explain the observed Period I uniformity of central and southwestern Texas. The resemblance between the two areas would apparently diminish after this period as the Archaic life-way was intensified after the final elimination from the scene of the large Pleistocene game. The Archaic peoples learned to exploit their environments in different ways, and followed somewhat distinct paths of economic development; thus there are no clusters linking the two areas during Periods II and III. It is clear, however, that the Archaic of southwestern Texas shows less divergence away from the transitional Paleo-Indian base culture of Period I than does that of

central Texas. This can be seen in the spatial-temporal distribution of index clusters A and B (Fig. 18).

Although these interpretations are hypothetical, at least they are founded in part on concrete comparative data. It is much more difficult, however, to explain the later resemblances between central and southwestern Texas which appear in Periods IV and V. Why, after long years of apparently little similarity, should the two areas become more alike, more uniform? I can pose no ready explanation. Many possibilities come to mind, but they are very difficult to evaluate. Three will be mentioned. First, in spite of what has been said earlier in the chapter, trade may have developed between central and southwestern Texas during these periods, or, second, both areas may have received similar immigrants with new artifact forms. The marked uniformity of Period V, over a distance of some 350 miles, would especially suggest the appearance of a new population in both central and southwestern Texas.

A third possibility is that both areas were somehow exposed to influences such as trade or diffusion from another region, or regions, and thereby developed similarities without any strong contact with each other. Period V is tentatively dated at A.D. 1030–1561. By this time, Formative societies with efficient maize-based horticulture had developed in several neighboring regions. The Fulton Aspect of the Caddoan Culture was located in the woodlands of eastern Texas (Suhm and others 1954: 154); there were single-storied pueblos of the Antelope Creek Focus in the Texas Panhandle (Suhm and others 1954: 56–73); the Jornado Branch people of the Mogollon Culture (Suhm and others 1954: 36–45) occupied pit-house villages in the El Paso area of far western Texas; and the La Junta people near Presidio also lived in pit-house communities (Suhm and others 1954: 48–49). Perhaps contact with these more evolved areas was inspired by a desire for maize and other products, and led to the borrowing of artifact styles which caused a high degree of uniformity in central and southwestern Texas in late times. All these hypotheses may be partially true, and need to be tested by a detailed distributional analysis of traits and artifact forms. This is quite a distinct type of study from the present quantitative comparison.

Conclusion

The purpose of this investigation has been to achieve culture-historical integration of archeological materials from two natural areas of Texas where unit definition is now impossible. The comparison of lithic artifact collections and the formulation of temporal and spatial patterns have provided a holistic view of the archeological data which would be difficult to get by any other means. The quantitative comparison with indexes of agreement (according to Robinson) and the matrix ordering made it possible to obtain an "overview" of the artifact collections and to treat the dimensions of time and space simultaneously.

Another aim of the study was to point out deficiencies in the available data, in excavation techniques, and in reporting. In the *Introduction,* a general question was asked: Are there patterns of general uniformity in the Archaic cultures of central and southwestern Texas? A statistical overview of the available information has provided a number of patterns through a simple form of cluster analysis, although these findings have to be highly tentative because of lacunae and deficiencies in the data. The difficulty of defining patterns illustrates to my satisfaction that it is long past time to stop and take stock of the current program of research. A number of suggestions can be made for improvement which would benefit the kind of synthesis which has been done here.

(1) Excavation techniques should be refined so that culture associations, if they exist in the area, can be discovered. Past excavation has been largely of the *sondage* type designed to reveal vertical successions of distinctive artifacts. In contrast, it is recommended that larger surface areas be cleared and carried down slowly. Hopefully, activity loci such as chipping areas, hearths on living surfaces, etc., might produce artifacts which, because of the context of their co-occurrence, could be considered in cultural association. If successful, the eventual result would be the definition of archeological culture units such as phases.

(2) An effort should be made to acquire representative, random samples from the sites. Both difficulties and advantages of the sampling techniques of Vescelius (1960), Rootenberg (1964), and Binford (1964) have been discussed. Modifications of the techniques will probably have to be made, but the Texas area offers a fine testing ground for experimenting with this problem. One improvement would be to estimate the volume of a site and its horizontal and vertical extent before excavation by means of extensive auger-testing.

(3) Larger artifact samples are needed from individual sites. Even though a field sample may look relatively large before the artifacts are analyzed and plotted, this impression may be deceptive. Once the deposits are periodized and artifacts from mixed strata are discarded, a large part of the total sample has been lost. More extensive excavation of the sites which were used here would have provided better samples for the five periods. The tendency toward numerous *sondage* excavations is largely responsible for this problem. More work at a smaller number of sites is the alternative.

(4) Artifact descriptions and typologies need to be systematized. This is not to say that any one typological approach has to be used by all Texas archeologists. Such would surely have the undesirable effect of ossifying research in this field as the general use of the typological schemes of Bordes and de Sonneville-Bordes has in France. However, if enough detailed description of artifact attributes can be included in site reports, the specimens can be regrouped for purposes of inter-site comparison without having to re-examine the artifacts themselves. The current tendency toward descriptive lumping was a major hindrance to the present study. The use of frequency distributions for metric attributes in place of ranges would help to alleviate the problem. Also, the present unqualified use of functional labels cannot go uncensured. When ethnographic parallels are lacking, these terms can only cause confusion.

(5) At several points in the text other recommendations were made which relate to the use of ethnographic and documentary sources, the gathering of information which might help evaluate the hypotheses posed to explain the cluster patterns, etc. They will not be repeated, but their importance is clear.

Appendixes

APPENDIX I

Radiocarbon Age Calculations Applicable to Central and Southwestern Texas, Tabulated by Periods

PERIOD I.

8350 B.C. (± 400 years), no. Tx-80 (Tamers and others 1964: 153). Charcoal, Coontail Spin Rockshelter, Val Verde County. Earliest occupation of site, 12 ft. depth.

8280 B.C. (± 160 years), no. Tx-153 (Pearson and others MS). Charcoal, Bonfire Rockshelter, Val Verde County. Bone Bed 2.

8050 B.C. (± 175 years), no. 0–1106 (Alexander 1963: 513). Shell, Levi Rockshelter, Travis County. Zone II.

7350 B.C. (± 160 years), no. 0–1129 (Alexander 1963: 513). Shell, Levi Rockshelter, Travis County. Zone II.

5950 B.C. (± 800 years), no. Tx-63 (Tamers and others 1964: 147–148). Charcoal, Kincaid Rockshelter, Uvalde County. Lower levels of Zone 5.

5400 B.C. (± 150 years), no. 0–1128 (Alexander 1963: 513). Shell, Levi Rockshelter, Travis County. Top of Zone IV.

4800 B.C. (± 150 years), no. 0–1105 (Alexander 1963: 513). Shell, Levi Rockshelter, Travis County. Bottom of Zone IV.

PERIOD II.

6810 B.C. (± 150 years), no. Tx-141 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum V.

6810 B.C. (± 150 years), no. Tx-107 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum V, Hearth 1.

6730 B.C. (± 150 years), no. Tx-108 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum V, Hearth 2.

6730 B.C. (± 180 years), no. Tx-197 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum V.

6590 B.C. (± 120 years), no. Tx-140 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum V.

4160 B.C. (± 220 years), no. Tx-138 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum III.

4110 B.C. (± 240 years), no. TxA-544 (Richard E. Ross, written communication, 1964). Charcoal, Eagle Cave, Val Verde County. Zone IV.

3600 B.C. (± 260 years), no. Tx-117 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum II.

2790 B.C. (± 280 years), no. Tx-137 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum II.

2630 B.C. (± 110 years), no. Tx-196 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum II.

2570 B.C. (± 120 years), no. Tx-203 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum II.

2220 B.C. (± 80 years), no. Tx-193 (Pearson and others MS). Charcoal, Fate Bell Rockshelter, Val Verde County. Zone III.

1315 B.C. (± 150 years), no. 0–1315 (Kelly 1961: 266). Charcoal, the Crumley Site, Travis County. Transition between strata 1 and 2.

PERIOD III.

4580 B.C. (± 620 years), no. Tx-41 (Tamers and others 1964: 152). Charcoal, Centipede Cave, Val Verde County. Upper part of Lower Zone.

2600 B.C. (± 130 years), no 317 (Schuetz 1957: 288). Charcoal, Eagle Cave, Val Verde County. Zone B (Period III).

1620 B.C. (± 650 years), no. Tx-103 (Tamers and others 1964: 150). Charcoal, Oblate Rockshelter, Comal County. Hearth, Zone 1.

1460 B.C. (± 70 years), no. Tx-136 (Pearson and others MS). Charcoal, Eagle Cave, Val Verde County. Stratum II, Substratum 1.

1380 B.C. (± 110 years), no. Tx-191 (Pearson and others MS). Charcoal, Fate Bell Rockshelter, Val Verde County. Zone III.

1100 B.C. (± 120 years), no. Tx-40 (Tamers and others 1964: 152). Shell, Centipede Cave, Val Verde County. Base of Lower Zone.

860 B.C. (± 110 years), no. Tx-47 (Tamers and others 1964: 154). Charred bone, Bonfire Rockshelter, Val Verde County. Test excavation IV, Zone D (bone layer).

830 B.C. (± 110 years), no. Tx-106 (Tamers and others 1964: 154). Charcoal, Bonfire Rockshelter, Val Verde County. Upper bone layer.

560 B.C. (± 200 years), no. Tx-131 (Pearson and others MS). Charcoal, Bonfire Rockshelter, Val Verde County. Bone bed 3.

520 B.C. (± 140 years), no. Tx-146 (Pearson and others MS). Charcoal, Cueva de la Zona, Nuevo León, Mexico. Level 13.

370 B.C. (± 90 years), no. Tx-145 (Pearson and others MS). Charcoal, Cueva de la Zona, Nuevo León, Mexico. Level 12.

360 B.C. (± 210 years), no. Tx-46 (Tamers and others 1964: 153–154). Charred bone, Bonfire Rockshelter, Val Verde County. Upper bone layer.

40 B.C. (± 140 years), no. Tx-209 (Pearson and others MS). Charcoal, Cueva de la Zona, Nuevo León, Mexico. Level 11.

110 A.D. (± 400 years), no. Tx-39 (Tamers and others 1964: 152). Charcoal, Centipede Cave, Val Verde County. Lower Zone.

PERIOD IV.

350 B.C. (± 160 years), no. Tx-76 (Tamers and others 1964: 152). Charcoal, Coontail Spin Rockshelter, Val Verde County. Depth 5.5 ft., Area A.

90 B.C. (± 130 years), no. Tx-121 (Pearson and others MS). Charcoal, Pohl Site, Comal County. Depth 18–24 in.

260 A.D. (± 80 years), no. Tx-194 (Pearson and others MS). Charcoal, Bonfire Rockshelter, Val Verde County. Fiber Layer.

450 A.D. (± 130 years), no. Tx-151 (Pearson and others MS). Charcoal, Bonfire Rockshelter, Val Verde County. Fiber Layer.

680 A.D. (± 110 years), no. Tx-81 (Tamers and others 1964: 153). Unburned grass, Coontail Spin Rockshelter, Val Verde County. Upper Zone C, Area A.

770 A.D. (± 210 years), no. Tx-27 (Tamers and others 1964: 146). Charcoal, Smith Rockshelter, Travis County. Layer I.

785 A.D. (± 120 years), no. Tx-28 (Tamers and others, 1964: 146). Charcoal, Smith Rockshelter, Travis County. Layer I.

1245 A.D. (± 115 years), no. Tx-23 (Tamers and others 1964: 145–146). Charcoal, Smith Rockshelter, Travis County. Mostly from Layer I, partly from Layer II.

PERIOD V.

50 A.D. (± 160 years), no. Tx-100 (Tamers and others 1964: 149). Charcoal, Kyle Rockshelter, Hill County. Upper Stratum IV.

870 A.D. (± 110 years), no. Tx-72 (Tamers and others 1964: 151). Charcoal, Penny Winkle Site, Bell County. Hearth, Feature 1.

910 A.D. (± 85 years), no. Tx-70 (Tamers and others 1964: 150). Charcoal, Penny Winkle Site, Bell County. Lower Zone III.

910 A.D. (± 120 years), no. Tx-74 (Tamers and others 1964: 143). Charcoal, Barton Springs Road Site, Travis County. Zones V–VI.

1030 A.D. (± 200 years), no. Tx-75 (Tamers and others 1964: 151). Charcoal, Punkinseed Site, Travis County. Depth 0.5–1.0 ft.

1245 A.D. (± 95 years), no. Tx-26 (Tamers and others 1964: 146). Charcoal, Smith Rockshelter, Travis County. Layers III–IV.

1276 A.D. (± 165 years), no. C-8 (Jelks 1962: 97). Charcoal, Kyle Site, Hill County. Hearth on contact between Zones IV and V.

1291 A.D. (± 150 years), no. C-1 (Jelks 1962: 97). Charcoal, Kyle Site, Hill County. Middle of Zone IV.

1365 A.D. (± 85 years), no. Tx-24 (Tamers and others, 1964: 146). Charcoal, Smith Rockshelter, Travis County. Layer III.

1390 A.D. (± 80 years), no. Tx-99 (Tamers and others 1964: 149). Charcoal, Kyle Rockshelter, Hill County. Lower Stratum V.

1390 A.D. (± 80 years), no. Tx-98 (Tamers and others 1964: 149). Charcoal, Kyle Rockshelter, Hill County. Upper Stratum V.

1410 A.D. (± 140 years), no. Tx-25 (Tamers and others 1964: 146). Charcoal, Smith Rockshelter, Travis County. Layers VI–VII.

1561 A.D. (± 130 years), no. C-5 (Jelks 1962: 97). Charcoal Kyle Rockshelter, Hill County. Zone V.

1660 A.D. (± 95 years), no. Tx-71 (Tamers and others 1964: 150). Charcoal, Penny Winkle Site, Bell County. Upper Zone III.

1710 A.D. (± 140 years), no. Tx-21 (Tamers and others 1964: 145). Charcoal, Smith Rockshelter, Travis County. Layers IX–X.

1740 A.D. (± 70 years), no. Tx-22 (Tamers and others 1964: 145). Charcoal, Smith Rockshelter, Travis County. Layer X.

1795 A.D. (± 90 years), no. Tx-29 (Tamers and others 1964: 149). Charcoal, Oblate Rockshelter, Comal County. Lower Zone III.

APPENDIX II

Published Designations for Lithomorphic Classes

Lithomorphic Class:	Published Label:	Site:
Class 1	Tortugas points	Coontail Spin (Nunley and Duffield MS)
	misc. triangular points	Devil's Mouth (Johnson 1964: 44, 45)
	Tortugas points	Devil's Mouth (ibid.: 44)
	Tortugas points	Wunderlich (Johnson 1962a: 27)
	knife form B	Oblate (Tunnell 1962: 100)
	Tortugas points	Smith (Suhm 1957: 39)
	knives	Smith (ibid.: 39, Fig. 6, A, F, G)
Class 2	Granbury points	Oblate (Tunnell 1962: 96)
	Fresno points	Smith (Suhm 1957: 35)
Class 3	Flaco-like point	Devil's Mouth (Johnson 1964: 44)
Class 4	group 1 arrow points	Roark (Kelly 1963: 200)
	group 3 arrow points	Roark (ibid.: 202)
Class 5	Harrell points	Roark (Kelly 1963: 198)
Class 6	Toyah points	Roark (Kelly 1963: 200)
	Toyah points	Devil's Mouth (Johnson 1964: 58)
Class 7	Ensor points	Roark (Kelly 1963: 203)
	Ensor points	Centipede (Epstein 1963: 45, 46)
	Ensor points	Coontail Spin (Nunley and Duffield MS)
	Ensor points	Devil's Mouth (Johnson 1964: 34, 36)
	Marshall points	Devil's Mouth (ibid.: 39)
	Williams points	Devil's Mouth (ibid.: 45)
	Paleo-Indian stemmed points	Devil's Mouth (ibid.: 55, 57)
	Lange points	Wunderlich (Johnson 1962a: 23)
	Castroville points	Wunderlich (ibid.: 21)
	Marcos points	Oblate (Tunnell 1962: 92)
	Castroville points	Oblate (ibid.: 88)
	Ensor points	Oblate (ibid.: 88, 90)
	Marshall points	Oblate (ibid.: 92)
	Castroville points	Smith (Suhm 1957: 38, 39)
	Ensor points	Smith (ibid.: 38)

Class 8	Scallorn points	Roark (Kelly 1963: 200)
	group 4 arrow points	Roark (ibid.: 202)
	Scallorn points	Oblate (Tunnell 1962: 98)
	Scallorn points	Smith (Suhm 1957: 35)
	Scallorn points	Kyle (Jelks 1962: 27–31)
Class 9	Paisano A points	Roark (Kelly 1963: 203)
	Frio points	Roark (ibid.: 203)
	Martindale points	Coontail Spin (Nunley and Duffield MS)
	Frio points	Coontail Spin (ibid.)
	Conejo points	Devil's Mouth (Johnson 1964: 32, 33)
	Edgewood-like points	Devil's Mouth (ibid.: 34)
	Fairland points	Devil's Mouth (ibid.: 36)
	Frio points	Devil's Mouth (ibid.: 37)
	Fairland points	Oblate (Tunnell 1962: 90)
	Frio points	Oblate (ibid.: 90, 92)
Class 10	Montell points	Devil's Mouth (Johnson 1964: 39, 40)
	Montell points	Roark (Kelly 1963: 208–210)
	Montell points	Oblate (Tunnell 1962: 92)
Class 11	Perdiz points	Roark (Kelly 1963: 199)
	Livermore points	Roark (ibid.: 199)
	Perdiz points	Devil's Mouth (Johnson 1964: 58)
	Perdiz points	Oblate (Tunnell 1962: 96, 98)
	Perdiz points	Smith (Suhm 1957: 33, 35)
	Perdiz points	Kyle (Jelks 1962: 24, 26)
Class 12	Langtry A, B, C, D, and E points	Roark (Kelly 1963: 206, 208)
	Langtry points	Centipede (Epstein 1963: 36–40)
	Almagre points	Centipede (ibid.: 35, 36)
	Val Verde, Langtry, and Almagre points	Coontail Spin (Nunley and Duffield MS)
	Almagre points	Devil's Mouth (Johnson 1964: 30, 32)
	Langtry points, var. 1, 2, 3 and misc.	Devil's Mouth (ibid.: 38, 39)
	Langtry points	Wunderlich (Johnson 1962a: 23)
	Almagre points	Oblate (Tunnell 1962: 87)
Class 13	Cliffton points	Roark (Kelly 1963: 198)
	Cliffton points	Oblate (Tunnell 1962: 94, 96)
	Cliffton points	Smith (Suhm 1957: 35)
	Cliffton points	Kyle (Jelks 1962: 26, 27)
Class 14	Uvalde points	Coontail Spin (Nunley and Duffield MS)

APPENDIX II—(Continued)

	Paleo-Indian point	Devil's Mouth (Johnson 1964: 55, Fig. 17, J)
	Pedernales points, var. 1, 2, 3, and misc.	Wunderlich (Johnson 1962a: 25, 27)
	Pedernales points, var. B and C	Oblate (Tunnell 1962: 92, 94)
	Pedernales points	Smith (Suhm 1957: 38)
Class 15	Shumla points	Roark (Kelly 1963: 208)
	Shumla points	Centipede (Epstein 1963: 40, 41)
	Shumla points	Coontail Spin (Nunley and Duffield MS)
	Early Barbed points	Devil's Mouth (Johnson 1964: 33, 34)
	Shumla points	Devil's Mouth (ibid.: 42, 43)
	Shumla points	Wunderlich (Johnson 1962a: 27)
Class 16	Abasolo points	Roark (Kelly 1963: 202, 203)
	thumbnail knives	Roark (ibid.: 210)
	irregular knives	Roark (ibid.: 210, 211)
	lanceolate straight-base knives	Roark (ibid.: 212)
	lanceolate convex-base knives	Roark (ibid.: 212)
	Catán points	Centipede (Epstein 1963: 41)
	Abasolo points	Centipede (ibid.: 41)
	Catán-Abasolo points	Coontail Spin (Nunley and Duffield MS)
	knife groups 8, 11, and 12	Coontail Spin (ibid.)
	Desmuke point	Devil's Mouth (Johnson 1964: 33)
	knife groups 4, 5, 9, and misc.	Devil's Mouth (ibid.: 60, 62)
	knife groups, 3, 4	Wunderlich (Johnson 1962a: 33)
	knife forms A, D, I	Oblate (Tunnell 1962: 98, 100, 102)
	knife type 2	Levi (Alexander 1963: 517)
	Abasolo points	Smith (Suhm 1957: 39)
Class 17	Young points	Roark (Kelly 1963: 200)
	Young points	Smith (Suhm 1957: 35, 36)
	Granbury-Parker points	Kyle (Jelks 1962: 35–37)
Class 18	Palmillas points	Roark (Kelly 1963: 208)
	Figueroa and prov. type 2 points	Coontail (Nunley and Duffield MS)

	Figueroa points	Devil's Mouth (Johnson 1964: 36, 37)
	Palmillas points	Devil's Mouth (ibid.: 40)
	Zorra points	Devil's Mouth ibid.: 45)
	Paleo-Indian stemmed points	Devil's Mouth (ibid.: 55)
	Williams points	Wunderlich (Johnson 1962a: 27, 30)
	Palmillas points	Smith (Suhm 1957: 39)
	Yarbrough points	Kyle (Jelks 1962: 39)
	Godley points	Kyle (ibid.: 40)
Class 19	group 2 arrow points	Roark (Kelly 1963: 200, 202)
	Perdiz-like points	Devil's Mouth (Johnson 1964: 58)
	Cuney points	Smith (Suhm 1957: 36)
	Alba points	Smith (ibid.: 36)
	Eddy points	Smith (ibid.: 36)
	Bonham points	Kyle (Jelks 1962: 33, 34)
Class 20	knife form 7	Devil's Mouth (Johnson 1964: 60)
	knife type 4	Levi (Alexander 1963: 517)
	knives	Smith (Suhm 1957: 39, Fig. 6, C, D)
Class 21	Paisano B	Roark (Kelly 1963: 205)
	Kinney points and Plainview points	Coontail Spin (Nunley and Duffield MS)
	Kinney points	Devil's Mouth (Johnson 1964: 44)
	Plainview-Golondrina	Devil's Mouth (ibid.: 46, 48–51)
	Paleo-Indian points	Devil's Mouth (ibid.: 54, Fig. 17, G–I)
	Plainview-Angostura	Levi (Alexander 1963: 513–514)
	Clovis point	Levi (ibid.: 516)
Class 22	Angostura points	Coontail Spin (Nunley and Duffield MS)
	Angostura-like points	Devil's Mouth (Johnson 1964: 52)
	Paleo-Indian points	Devil's Mouth (ibid.: 54, 57, Fig. 17, D, F, Fig. 18, H)
	Angostura point	Wunderlich (Johnson 1962a: 19)
	Angostura point	Oblate (Tunnell 1962: 87)
	Iztapan point	Levi (Alexander 1963: 516)
	Angostura points	Smith (Suhm 1957: 38)
Class 23	Concave-base knives	Roark (Kelly 1963: 210)
	knife groups 6, 13	Coontail Spin (Nunley and Duffield MS)
	knife group 5	Wunderlich (Johnson 1962a: 33)
	knife form C	Oblate (Tunnell 1962: 100)
Class 24	Bulverde and Comstock points	Coontail Spin (Nunley and Duffield MS)

	Bulverde points	Devil's Mouth (Johnson 1964: 32)
	Lange points	Devil's Mouth (ibid.: 37, 38)
	Bulverde points	Wunderlich (Johnson 1962a: 19, 20)
	provis. type 1	Wunderlich (ibid.: 30)
	Bulverde points	Oblate (Tunnell 1962: 87, 88)
	stemmed point	Levi (Alexander 1963: 516)
	Darl points	Smith (Suhm 1957: 38)
	Bulverde points	Smith (ibid.: 39)
	Wells points	Kyle (Jelks 1962: 37)
	Darl points	Kyle (ibid.: 37, 39)
Class 25	Pandale points	Roark (Kelly 1963: 208)
	Pandale points and prov. type 1	Coontail Spin (Nunley and Duffield MS)
	Pandale points	Devil's Mouth (Johnson 1964: 40, 42)
	Travis points	Devil's Mouth (ibid.: 43, 44)
	Nolan points	Wunderlich (Johnson 1962a: 25)
	Travis points	Wunderlich (ibid.: 27)
	Paisano points	Oblate (Tunnell 1962: 94)
	Nolan points	Smith (Suhm 1957: 39)
	Travis points	Kyle (Jelks 1963: 37)
Class 26	misc. Archaic points	Devil's Mouth (Johnson 1964: 45, 46)
	Paleo-Indian stemmed	Devil's Mouth (ibid.: 57, Fig. 18, B)
	Paleo-Indian point	Devil's Mouth (ibid.: 55, Fig. 17, K)
	Pedernales points, var. A	Oblate (Tunnell 1962: 92)
	misc. points	Oblate (ibid.: 94)
	Uvalde point	Smith (Suhm 1957: 39)
	misc. points	Kyle (Jelks 1962: 40–42)
Class 27	unclassified specimen	Centipede (Epstein 1963: Fig. 12, C)
	Lerma points	Coontail Spin (Nunley and Duffield MS)
	Lerma-like point	Devil's Mouth (Johnson 1964: 52)
	knife form 8	Devil's Mouth (ibid.: 62)
	knife form L	Oblate (Tunnell 1962: 103)
	Lerma points	Levi (Alexander 1963: 516)
	double-pointed knife	Kyle (Jelks 1962: 45, 47)
	knives	Smith (Suhm 1957: 40, Fig. 6, B)
	Unclassified dart points	Smith (ibid.: 39, Fig. 5, I)
Class 28	knife groups 4 and 5	Coontail Spin (Nunley and Duffield MS)
	Paleo-Indian points	Devil's Mouth (Johnson 1964: 52, 54, 57, Fig. 17, B, C, Fig. 18, G)

	knife form 1	Devil's Mouth (ibid.: 59)
	knife form 3	Devil's Mouth (ibid.: 60)
	Refugio points	Wunderlich (Johnson 1962a: 27)
	knife forms E, F, G	Oblate (Tunnell 1962: 100, 102)
	knife type 3	Levi (Alexander 1963: 517)
	knives	Smith (Suhm 1957: 40, Fig. 6, E)
	Covington knife	Kyle (Jelks 1962: 42, 44)
	Cleburn knife	Kyle (ibid.: 44)
Class 29	oval knives	Roark (Kelly 1963: 212)
	oval knives	Centipede (Epstein 1963: 55, 57)
	knife groups, 9, 10	Coontail Spin (Nunley and Duffield MS)
	knife form 6	Devil's Mouth (Johnson 1964: 60)
	knife form J, K	Oblate (Tunnell 1962: 102, 103)
	knives	Smith (Suhm 1957: 39, Fig. 6, H)
	heavy blades	Smith (ibid.: 40)
	broad oval knives	Kyle (Jelks 1962: 48)
Class 30	knife group 2	Wunderlich (Johnson 1962a: 32)
Class 31	tapered-base knives	Roark (Kelly 1963: 211, 212)
	knife groups 2, 3	Coontail Spin (Nunley and Duffield MS)
	knife form 2	Devil's Mouth (Johnson 1964: 59)
	knife group 1	Wunderlich (Johnson 1962a: 32)
Class 32	knife form H	Oblate (Tunnell 1962: 102)
Class 33	scraper group 8	Wunderlich (Johnson 1962a: 36, 39)
	scraper type 5	Levi (Alexander 1963: 519)
Class 34	gunflints	Oblate (Tunnell 1962: 109)
Class 35	boatstone	Smith (Suhm 1957: 45)
Class 36	scraper type 10	Levi (Alexander 1963: 519)
Class 37	crude bifacial tools	Centipede (Epstein 1963: 61, 62)
	heavy blades	Smith (Suhm 1957: 40)
	crude bifacials	Kyle (Jelks 1962: 53)
	curved, pointed knives with unworked bases	Kyle (ibid.: 47)
Class 38	snub-nosed end scrapers	Coontail Spin (Nunley and Duffield MS)
	triangular end scrapers	Devil's Mouth (Johnson 1964: 62, 63)
	group 4 scrapers	Wunderlich (Johnson 1962a: 36)
	form I scrapers	Oblate (Tunnell 1962: 106)
	form J scrapers	Oblate (ibid.: 106)

APPENDIX II—(Continued)

	scraper types 3, 12	Levi (Alexander 1963: 517, 519)
	scrapers	Smith (Suhm 1957: 42, 44, Fig. 7, A, B, H)
	snub-nosed end scrapers	Kyle (Jelks 1962: 50–51)
Class 39	gouges	Coontail Spin (Nunley and Duffield MS)
	gouge-scrapers	Devil's Mouth (Johnson 1964: 63)
Class 40	oval scrapers	Roark (Kelly 1963: 214)
	circular scrapers	Roark (ibid.: 214)
	beveled scrapers	Roark (ibid.: 214)
	initial cortex flake scrapers	Centipede (Epstein 1963: 66)
	discoidal scrapers	Devil's Mouth (Johnson 1964: 63)
	discoidal scrapers	Oblate (Tunnell 1962: 103)
	scraper types 1, 6	Levi (Alexander 1963: 517, 519)
Class 41	platform scrapers	Roark (Kelly 1963: 214)
	cortex scrapers	Roark (ibid.: 214)
	oval cortex scrapers	Centipede (Epstein 1963: 64)
	long flake scrapers	Centipede (ibid.: 66)
	irregular scrapers	Centipede (ibid.: 69, 70)
	cortex scrapers	
	percussion scrapers	
	sequent flake scrapers	
	misc. scraper groups 1, 2, 3, 4	Coontail Spin (Nunley and Duffield MS)
	single-edge side scrapers	Devil's Mouth (Johnson 1964: 63)
	two-edge side scrapers	Devil's Mouth (ibid.: 63)
	scraper groups 5, 6, and 9	Wunderlich (Johnson 1962a: 36, 39)
	scraper forms C, D, G, and H	Oblate (Tunnell 1962: 104, 106)
	scrapers	Smith (Suhm 1957: 42, 44, Fig. 7, H)
	side scrapers	Kyle (Jelks 1962: 53)
Class 42	spokeshaves	Roark (Kelly 1963: 215, 217)
	spokeshaves	Centipede (Epstein 1963: 70)
	spokeshaves	Coontail Spin (Nunley and Duffield MS)
	spokeshaves	Wunderlich (Johnson 1962a: 33)

	scraper form 7	Oblate (Tunnell 1962: 104)
	scraper type 7	Levi (Alexander 1963: 519)
	scrapers	Smith (Suhm 1957: 44, Fig. 7, F)
Class 43	serrated flakes	Devil's Mouth (Johnson 1964: 65)
Class 44	choppers	Roark (Kelly 1963: 217)
	choppers	Coontail Spin (Nunley and Duffield MS)
	choppers	Wunderlich (Johnson 1962a: 39)
	choppers	Levi (Alexander 1963: 517)
	choppers	Smith (Suhm 1957: 44, 45)
Class 45	fist axes	Devil's Mouth (Johnson 1964: 65)
	handaxe	Smith (Suhm 1957: 44, 45)
Class 46	gravers	Roark (Kelly 1963: 217)
	scraper-gravers	Coontail Spiin (Nunley and Duffield MS)
	gravers	Devil's Mouth (Johnson 1964: 65)
	gravers	Oblate (Tunnell 1962: 106)
	gravers	Levi (Alexander 1963: 521)
	gravers	Smith (Suhm 1957: 44)
	gravers	Kyle (Jelks 1962: 50)
Class 47	drills	Coontail Spin (Nunley and Duffield MS)
	drills	Devil's Mouth (Johnson 1964: 65)
	drills	Wunderlich (Johnson 1962a: 33)
	flake drills	Oblate (Tunnell 1962: 109)
	reworked dart point drills	Oblate (ibid.: 108, 109)
	drill types 1, 2	Levi (Alexander 1963: 517)
	awl	Levi (ibid.: 521)
	drills	Smith (Suhm 1957: 40, 42)
	drills	Kyle (Jelks 1962: 48–50)
Class 48	burins	Centipede (Epstein 1963: 70, 72, 73)
	burins	Coontail Spin (Nunley and Duffield MS)
	possible burins	Devil's Mouth (Johnson 1964: 67)
	burins	Oblate (Tunnell 1962: 108)
	burins	Levi (Alexander 1963: 521)
Class 49	grinding slabs	Coontail Spin (Nunley and Duffield MS)
	metates	Devil's Mouth (Johnson 1964: 70)
	milling slabs	Oblate (Tunnell 1962: 109)
	seed-grinding slabs	Levi (Alexander 1963: 521)
	milling slabs	Smith (Suhm 1957: 46)

APPENDIX II—(Continued)

Class 50	manos	Roark (Kelly 1963: 219)
	manos	Coontail Spin (Nunley and Duffield MS)
	manos	Devil's Mouth (Johnson 1964: 70)
	hand milling stones	Oblate (Tunnell 1962: 109)
	hand milling stones	Levi (Alexander 1963: 521)
	manos	Smith (Suhm 1957: 46)
	manos	Kyle (Jelks 1962: 55)

APPENDIX III

Lithomorphic Classes Tabulated by Period

PERIOD I

	LEVI		COONTAIL SPIN		DEVIL'S MOUTH	
Class	No.	%	No.	%	No.	%
7					1	.8
9			1	.6		
12			2	1.2		
14			1	.6	1	.8
15			2	1.2		
16	4	1.6	4	2.4	10	8.5
18					1	.8
20	3	1.2			6	5.1
21	30	11.7	1	.6	13	11.0
22	6	2.3			4	3.4
24	1	.4				
25			5	3.0		
26					2	1.7
27	2	.8	8	4.8	13	11.0
28	9	3.5	2	1.2	3	2.5
29			1	.6		
30			5	3.0	3	2.5
33	4	1.6				
34	1	.4	2	1.2		
36	10	3.9				
38	22	8.6			4	3.4
39					2	1.7
40	13	5.1				
41	68	26.3	109	64.9	51	43.2
42	15	5.8	1	.6		
44	2	.8	7	4.2		
46	8	3.1	1	.6	1	.8
47	4	1.6	1	.6	1	.8
48	49	19.1	2	1.2	2	1.7
49	6	2.3	13	7.7		
TOTALS:	257		168		118	

PERIOD II

	DEVIL'S MOUTH		WUNDERLICH	
Class	No.	%	No.	%
1			1	3.7
9	1	2.6		
12			1	3.7
14			1	3.7
15	10	26.3		
16	9	23.7	2	7.4
18			1	3.7
21	1	2.6		
22			1	3.7
23			1	3.7
24			2	7.4
25	6	15.8	7	26.0
26			2	7.4
28	1	2.6	1	3.7
31	1	2.6	2	7.4
33			1	3.7
41	1	2.6	4	14.8
46	1	2.6		
47	2	5.3		
48	2	5.3		
49	1	2.6		
50	2	5.3		
TOTALS:	38		27	

PERIOD III

	ROARK		CENTIPEDE		COONTAIL SPIN	
Class	No.	%	No.	%	No.	%
7	1	2.0	3	3.8	6	1.7
8	1	2.0				
9	6	12.2			4	1.1
11	1	2.0				
12	13	26.5	22	28.2	63	17.5
14					3	.8
15	1	2.0	5	6.4	62	17.3
16	3	6.1	5	6.4	18	5.3
18	3	6.1			2	.6
21					3	.8
23					7	1.9
24					4	1.1
25					16	4.5
27			1	1.3	2	.6
28					9	2.5
29	1	2.0	4	5.1	6	1.7
31	4	8.2			16	4.5
37			11	14.1		
38					1	.3
39					2	.6
40	4	8.2	6	7.7		
41	2	4.1	16	20.5	88	21.7
42	5	10.2	1	1.3	2	.6
44	2	4.1			22	6.1
46	2	4.1				
47					1	.3
48			4	5.1	13	3.2
49					1	.3
50					8	2.2
TOTALS:	49		78		359	

PERIOD III

	DEVIL'S MOUTH		WUNDERLICH		OBLATE	
Class	No.	%	No.	%	No.	%
1	2	.8				
7	18	7.1	2	3.1	21	36.2
9	9	3.5			1	1.7
10	42	16.5			3	5.2
11	1	.4				
12	25	9.8	6	9.3	1	1.7
14			39	60.0	6	10.3
15	16	6.3	1	1.5		
16	42	16.5	4	6.2	4	7.0
18	10	3.9				
20	1	.4				
24	5	2.0	1	1.5	2	3.4
25	14	5.5				
26	4	1.6			2	3.4
28	8	3.1			2	3.4
29	1	.4			1	1.7
30			3	4.6		
31	1	.4	2	3.1		
38	5	2.0	1	1.5		
39	1	.4				
40	2	.8			8	13.8
41	23	9.1	3	4.6	5	8.6
43	4	1.6				
44			2	3.1		
45	3	1.2				
46	2	.8				
47	4	1.6	1	1.5	1	1.7
49	1	.4				
50	10	3.9			1	1.7
	254		65		58	

PERIOD IV

	COONTAIL SPIN		DEVIL'S MOUTH		OBLATE		SMITH	
Class	No.	%	No.	%	No.	%	No.	%
1	1	1.6	1	.9	2	1.9	1	2.4
2							1	2.4
7	17	27.9	14	12.3	27	25.2	2	4.9
8							3	7.3
9	4	6.6	11	9.7	2	1.9		
10			6	5.3	5	4.7		
11			3	2.7				
12	2	3.3	1	.9				
14					1	.9	1	2.4
16	3	4.9	11	9.7	12	11.2	2	4.9
17							2	4.9
18	2	3.3	30	26.5				
19			1	.9				
20							2	4.9
22					1	.9		
23	1	1.6			2	1.9		
24			2	1.8	1	.9	16	39.0
25	1	1.6	2	1.8				
26			1	.9	4	3.7		
28	3	4.9	3	2.7	11	10.3	1	2.4
29	1	1.6	1	.9	7	6.5	1	2.4
32					2	1.9		
35							1	2.4
37							1	2.4
38			3	2.7			1	2.4
40			2	1.8	1	.9		
41	19	31.1	12	10.6	14	13.1	1	2.4
43			2	1.8				
44	2	3.3						
45			1	.9				
46			1	.9	1	.9	3	7.3
47					4	3.7	1	2.4
48	4	6.6			4	3.7		
49			1	.9	1	.9	1	2.4
50			4	3.5	1	.9		
	61		113		107		41	

PERIOD V

	ROARK		DEVIL'S MOUTH		OBLATE		SMITH		KYLE	
Class	No.	%	No.	%	No.	%	No.	%	No.	%
1			2	5.4			6	1.7		
2					1	.7	1	.3		
5	1	.9								
6	5	4.7								
7	2	1.9			5	3.3	2	.6		
8	5	4.7			27	18.0	28	8.0	6	5.6
9	3	2.3	2	5.4	5	3.3				
10			1	2.7						
11	20	18.9	9	24.3	22	14.7	201	57.8	36	33.6
12	1	.9								
13	6	5.7			7	4.7	13	3.7	10	9.3
14							4	1.1		
16	11	10.4	10	27.0	7	4.7				
17	3	2.8					12	3.4	1	.9
18	2	1.9	3	8.1					2	1.9
19	2	1.9	1	2.7			7	2.0	2	1.9
20							4	1.1		
22							1	.3		
24							4	1.1	2	1.9
25			1	2.7	1	.7	1	.3	1	.9
26					1	.7	1	.3	3	2.8
27					1	.7	2	.6	1	.9
28					21	14.0	1	.3	14	13.1
29	3	2.8			4	2.7	5	1.4	1	.9
34					6	4.0				
37							1	.3	13	12.2
38			1	2.7	3	2.0	13	3.7	1	.9
40	7	6.6			1	.7				
41	13	12.3	4	10.8	24	16.0	7	2.0	2	1.9
42	6	5.7			5	3.3	6	1.7		
44	5	4.7					5	1.4		
45							1	.3		
46	11	10.4	1	2.7	2	1.3	6	1.7	2	1.9
47					4	2.7	12	3.4	4	3.7
49					1	.7	2	.6		
50			2	5.4	2	1.3	2	.6	6	5.6
	106		37		150		348		107	

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